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Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

A Comparison of Film Badges and Thermoluminescent Dosimeters Used for Environmental Monitoring[1]

Charles K. Fitzsimmons, William Horn, and William L. Klein [2]

Data obtained from two concurrent dosimetry networks operated by the National Environmental Research Center, Las Vegas, Nev., are compared. One network utilizes film badges and the other, thermoluminescent dosimeters. Gamma exposures from a few mR to approximately 1 R due to both natural background and fission products in the environment are more easily and accurately measured by the TLD system. Where the minimum detectable exposure for film is about 45 mR, the TLD sensitivity is on the order of 1 mR (which allows measurement of monthly background exposures). The insensitivity of TLD's to environmental heating, humidity, light damage, and pressure makes them ideal for use in the extreme conditions encountered in the desert. Heat damage to the film was seasonal with the greatest losses occurring in the summer. During July 1967, 71 percent of the film badges issued were heat or light damaged, while no loss of TLD data occurred. No background information was obtained from film data during 1967, but the geographical variations in background exposure rates were clearly disclosed by the TLD's.

In accordance with a Memorandum of Understanding, the National Environmental Research Center—Las Vegas (NERC–LV) provides an offsite radiological safety program for the Atomic Energy Commission in support of nuclear tests conducted on the Nevada Test Site (NTS) complex.

As one portion of the offsite radiological safety program, the Dosimetry Unit of the NERC–LV has a primary mission to document offsite gamma radiation exposures above environmental background resulting from specific nuclear tests.

Since inception of the program in 1954, integrating dosimeter readings have been used to supplement offsite exposure data. Film badges were the dosimeters of choice at that time. However, because interest in the field of radiological health has shifted during recent years to the measurement of smaller exposures, the inherent properties of the film badge dosimeter severely limited expansion of the program into this area. The sensitivity, accuracy, and reliability of the film badge were found to be inadequate for the gamma radiation levels of interest.

During this same period, considerable research on thermoluminescent dosimeters (TLD's) was being performed by a number of investigators. The properties of the TLD as described in the literature seemed more suitable for the needs of the NERC–LV. In 1965, after considerable field testing, a TLD system was incorporated into the film badge dosimetry network. As a result, over 2 years of side-by-side data have been accumulated from approximately 80 field locations.

This report presents a comparison and discussion of the film badge and TLD data.

Film badge network

Before 1961, film badges were issued to offsite residents and placed at strategic locations for specific nuclear tests. The film packet used was DuPont type 556, containing a two-component packet in a paper wrapper, emulsion No. 508, with a claimed detection range from 30 mR to 5 R, and emulsion No. 834, with a detection range from 3 R to 10 R. In 1963, the number of permanent stations in the film badge network was 66, in addition to a monthly dosimeter exchange with 130 offsite residents. The present program consists of 100 permanent offsite stations and 119 offsite residents.

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[1] This study performed under a Memorandum of Understanding for the Nevada Operations Office, U.S. Atomic Energy Commission.

[2] Mr. Fitzsimmons, Mr. Horn, and Mr. Klein are with Environmental Surveillance, National Environmental Research Center, Las Vegas, Nev., EPA, formerly the Southwestern Radiological Health Laboratory, U.S. Department of Health, Education, and Welfare, PHS, Bureau of Radiological Health, Las Vegas, Nev.

Although the DuPont 556 film packet was the most suitable field dosimeter available at the time, serious problems were encountered. A high percentage of the film badges was damaged by heat, light, and moisture. In 1963, an alternative to the DuPont 556 film packet was investigated. Since offsite radiation monitoring involved exposures less than 5 R, it was felt that a single component low-range film packet would be adequate. As a result, a new film badge holder was designed incorporating DuPont type 545 film with a detection range from 30 mR to approximately 4 R. Although this reduced the initial film badge cost by 50 percent and increased the sensitivity of the dosimeter somewhat, the new film packet was as susceptible to heat, light, and moisture damage as its predecessor.

During this same period, interest in the field of radiological health had shifted to the measurement of smaller exposures. At this point, the inherent limitations of the film badge became a major obstacle to the growing needs and obligations of the Dosimetry Unit. In 1965, several nonfilm dosimeters were investigated and evaluated.

TLD network

After investigating various thermoluminescent and glass dosimeters, the Edgerton, Germeshausen, and Grier, Inc., (EG&G) Thermoluminescent Dosimetry System was field tested. The EG&G system utilized the TL–12 thermoluminescent dosimeter and the TL–2B dosimeter reader. The detection medium of the dosimeter consists of a layer of CaF_2:Mn bonded to a helical heater element that is encapsulated in a gas-filled glass envelope. The detector is housed in an aluminum-tin-lead shield designed to compensate for the detector over-response in the low energy region of the gamma ray spectrum and to protect the detector from light exposure. The dosimeter reader accepts the TLD in a light tight chamber, heats it with a regulated current and converts the emitted light energy into an electrical signal for display on the built-in strip chart recorder.

Preliminary field investigation involved the use of 10 TLD's for each of two NTS events: Sulky, a Plowshare experiment, and the Transient Nuclear Test (TNT) of a Kiwi Reactor. During each event, two TLD's were retained in Las Vegas as controls and eight were placed in strategic locations or carried by EPA monitoring personnel. Although the field dosimeters yielded slightly higher readings than the controls, evaluation on a larger scale was advisable. Consequently, EG&G furnished 55 dosimeters for monitoring of Project Palanquin in April 1965. During each evaluation, 10 dosimeters were retained as controls. Each of the remaining 45 dosimeters was packaged in a polyethylene envelope with one DuPont type 555 film packet and one DuPont type 556 film packet. The type 556 film had been preexposed to 100 mR of cobalt-60 radiation in an attempt to gain greater sensitivity to low exposures. The dosimetry packages were placed on stakes within the expected trajectory and carried in monitoring aircraft and by field personnel.

After a 10 day exposure in the field, the TLD's were taken to EG&G in Santa Barbara, Calif. for reading. The film badges were sent to Mercury, Nev., for processing. The results obtained from Santa Barbara indicated that the manufacturer's claims concerning the minimum dose resolution of 5 mR and a coefficient of variation of 10 percent were, in fact, conservative. In addition, it was found that the preexposed film performed very poorly and this technique was abandoned. The TLD system held promise to fulfill the growing need for greater sensitivity and accuracy in measuring environmental gamma exposure.

An EG&G TLD system was obtained and put into operation during August 1965. The results of the first 4 months of operation indicated that

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before the full potential of the system would be realized, a number of objectives had to be met. These objectives were to (1) perfect a system of reader calibration, (2) establish a correction factor for each dosimeter, (3) determine the internal background due to potassium-40 activity within the dosimeter, (4) ascertain the significance of fading over extended periods of time, and (5) determine the precision of the system. The results of studies and solutions to problems in these areas, as well as the development and growth of the TLD network, are discussed in another report (*1*).

The bulk of the data used for comparison in this report was collected during 1966 and 1967 when 80 TLD stations were in operation. The data represent exposures from fission product gamma radiation in the range from 5 mR to approximately 1 R. The energy response of any dosimeter is a function of the shielding employed as well as the detection medium. The energy response of the TL–12 is shown in figure 1.

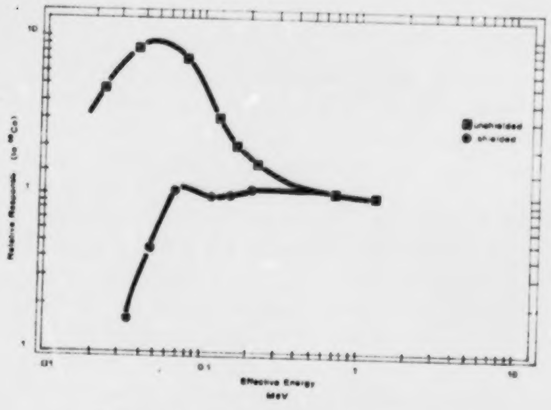

Figure 1. Gamma energy response of thermoluminescent CaF_2:Mn

Comparison of field data

Data from the routine monitoring network

Data from the routine stations are used primarily to establish background exposure rates, even though the network owes its existence to the need for measurement of possible biologically significant exposures due to specific nuclear tests. Background, in this sense, refers to the exposure from all ionizing radiation in the environment which cannot be attributed to any specific manmade source. Thus, it is possible in some cases that *background* includes the exposure from a residual trace of long-lived fission products as well as from the naturally-occurring radionuclides and cosmic radiation. The observed variation in background levels from place to place is a function of the intensity of all three contributors, manmade, terrestrial, and cosmic.

The film badge has proven incapable of providing this background information. Out of 6,454 film badges placed at the offsite stations during 1967, only 257 or 4.0 percent had a reported value greater than the detection limit. Film badges that were damaged or read below the detection limit were reported as zero. Table 1 presents a summary of dosimeters issued, those damaged or lost, and those having a reading greater than zero. Of 2,461 TLD's issued in 1967, only 10 failed to produce usable data. If film badges are left in the field long enough to obtain a reading over the 30 to 50 mR threshold, the chance of heat or light damage becomes a near certainty. Film badges left in the field for 2 months which do not become unreadable because of severe heat damage often read 40 to 50 mR, about 100 percent greater than the expected exposure. Little use is made of the routine film badge data since the TLD's perform so well.

The basic purpose of any monitoring network is to detect exposures above natural background. However, small offsite exposures due to nuclear testing are seldom detected even by the TLD's at routine stations because the signal-to-noise ratio is unfavorable. Typical monthly backgrounds range from 10 to 20 mR. Variation in the monthly background exposure at a given location can be as great as ±50 percent. Thus, net exposures less than about 10 mR which are still of interest may be missed. Greater sensitivity is obtained by placing special dosimeters in the field for specific events and using the background values derived from the routine data to calculate net exposures. In order to

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Table 1. Summary of dosimeters issued to routine stations in 1967

Month (1967)	Number of dosimeters used	Number lost or damaged	Percent lost or damaged	Number reporting values greater than zero[a]	Percent greater than zero
Thermoluminescent dosimeters:					
January	209	0	0	209	100
February	210	0	0	210	100
March	207	0	0	207	100
April	216	0	0	216	100
May	177	6	3.4	171	96.6
June	204	0	0	204	100
July	222	0	0	222	100
August	248	1	.4	247	99.6
September	246	3	1.2	243	98.8
November[b]	261	0	0	261	100
December	261	0	0	261	100
Totals	2,461	10	.4	2,451	99.6
Film badges:					
January	588	18	3.1	17	2.9
February	482	12	2.5	18	3.7
March	592	132	22.3	31	5.2
April	574	64	11.1	50	8.7
May	491	146	29.7	20	4.1
June	600	400	66.6	24	4.0
July	580	413	71.2	0	0
August	632	177	28.0	18	2.8
September	628	60	9.6	21	3.3
November[b]	630	15	2.4	31	4.9
December	657	12	1.8	27	4.1
Totals	6,454	1,449	22.5	257	4.0

[a] Film badges that were damaged or read less than the detectable level were reported as zero.

[b] Reporting periods were longer than 1 month on the average, and only 11 reports were made in 1967. The gap was made up by skipping the October report.

accumulate data, the dosimeters used must be sensitive to the low background exposure of one month's time.

Data from monitoring a nuclear waste disposal site

Four routine stations in the monitoring network are located on the fence surrounding the Nuclear Engineering Company's radioactive waste disposal site near Beatty, Nev. Each station has five film badges and three TLD's. The stations were established at the request of the Nevada State Health Department. Subsequently, the stations have provided side-by-side data which have been used to compare film badge and TLD performance. Exposures range from about 40 mR to nearly 700 mR.

Average values of three TLD and five film badge responses for 1 year at the disposal site are paired and ranked by TLD response in table 2. The data were collected from January 4, 1967, to January 11, 1968. Each value represents the exposure in mR for approximately 1 month. The great monthly variations are the result of burials and other movement of radioactivity within the fenced area. A linear regression was performed on the data and yielded $y = -1.01 + 1.03x$, which is an excellent agreement between the two dosimeters (figure 2). The slope of 1.03 has a coefficient of variation of only 3.22 percent and a correlation coefficient of 0.98.

Thirty-four film badge readings in this group were greater than 45 mR, while only six were less. The excellent correlation is attributable to the ideal exposure range, 40 to 700 mR, for the film. What is not shown by these figures is that all zero values or unreadable (damaged) film badges were deleted from table 2. Frequency of heat damage followed the same seasonal trend as it did for the other badges issued, 27 percent were heat damaged, and 1 percent indicated zero. No data were missing from the 132 TLD's issued during the same period.

Another statistical test was made on the Nuclear Engineering Company data. Individual readings rather than averages were used so that

Table 2. Paired average thermoluminescent dosimeters-film badge monthly exposures from Nuclear Engineering Company Site

Location	Thermoluminescent dosimeters (mR)	Film badge* (mR)
North fence	37	79
	38	44
	43	23
	50	34
	52	81
	60	49
	62	48
	62	55
	63	58
	93	98
South fence	46	39
	64	40
	64	96
	71	113
	72	65
	98	104
	187	183
	269	267
	364	367
	537	671
East fence:	61	70
	67	34
	75	96
	98	106
	101	90
	102	110
	126	95
	147	131
	150	182
West fence	48	48
	62	95
	63	47
	72	52
	79	110
	81	71
	121	123
	185	141
	297	321
	551	505
	679	663

* Minimum detectable level varied, but was generally about 30 mR.

a better estimate of the error term would be made. The hypothesis that the mean film badge response is equal to the mean TLD response for a given exposure was tested using a two factor design. Calculations were made using an IBM 1130 computer. The two factors were: (a) monthly effects, and (b) type of dosimeter (film badge or TLD). As expected, there was a very large monthly effect. There was also a significant difference at the 95-percent confidence level between film badge and TLD means; however, the regression analysis previously done suggests that the difference was probably small. The interaction term (A×B) was also significant, indicating a possible seasonal effect on the film response. The validity of this interpretation is supported by the fact that heat damage to the film is seasonal and, therefore, sensitivity might be assumed to be seasonal also. Furthermore, studies have shown (*1*) that environmental temperature, humidity, and pressure have no detectable effect on TLD response. It is likely then, that the interaction term reflects a greater degree of variation in film response than in TLD response.

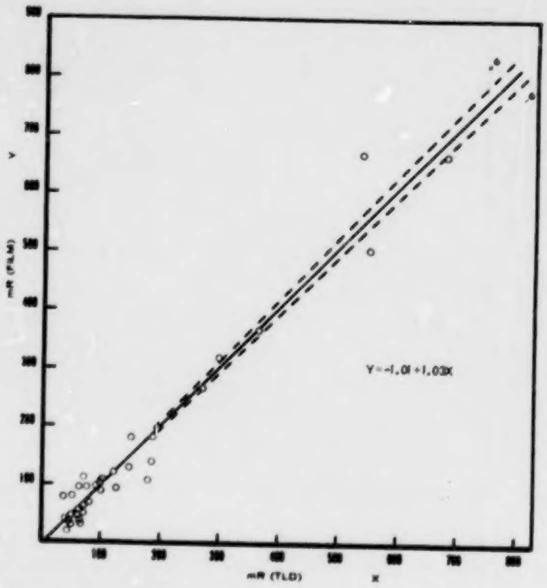

Figure 2. Correlation of film and TLD response from Nuclear Engineering Company data

Data from a Plowshare experiment

EPA monitoring activities for Project Buggy I, a Plowshare nuclear cratering experiment conducted on March 12, 1968, included six arcs of thermoluminescent dosimeters placed across the expected cloud trajectory. The dosimeters yielded a series of exposure profiles across the cloud path at 8 (Arc 1), 10, 35, 51 (Arc 4), 82, and 170 miles downwind from ground zero. The data also defined the line of maximum exposure, the approximate cloud width with distance, and the decrease of exposure as a function of distance. On two arcs, Arc 1 and Arc 4, film badges were placed alongside the TLD's.

Two TLD's and two film badges were placed on each stake of Arc 1. One of each was collected at H + 3 hours and the data plotted as "first

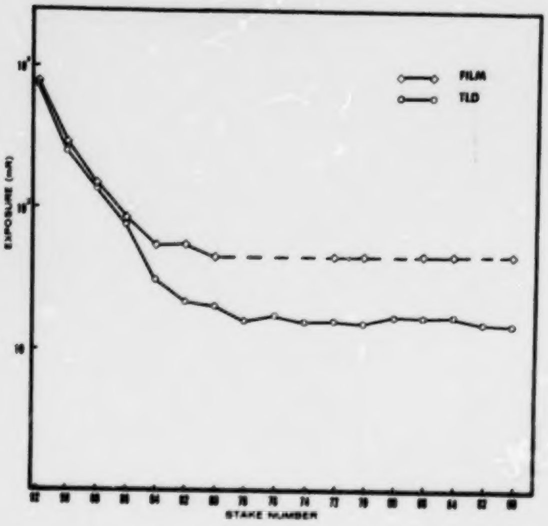

Figure 3. Cloud profile, Arc 1, Buggy 1, first pickup

pickup" in figure 3. The remaining TLD's and film badges were collected on D + 7 days. These data are plotted as "second pickup" in figure 4. The difference in low level sensitivity is shown plainly in these two plots. Above 80 mR, film and TLD responses are comparable, but there is increasing disagreement between the film badge and TLD data as the exposure level decreases. Below 45 mR there is no reported film response at all. Under these experimental conditions, 45 mR appears to be the minimum detectable exposure for the film (DuPont 556 packet, the same as that used at the Nevada Test Site for personnel monitoring).

The film and TLD data were paired for a statistical comparison of response to common exposures. Of the 34 film badges issued, only 19 provided positive data. Consequently, only the 19 film badge-TLD data pairs shown in table 3 were used in the analysis.

The first linear regression analysis, performed on all 19 data pairs, yielded the relationship, $y = 21.36 + 1.086x$, where y represents the film response and x the TLD response. The data are plotted in figure 5. The slope of the regression line was equal to 1.086 with a coefficient of variation of 1.64 percent and a correlation coefficient of 0.99.

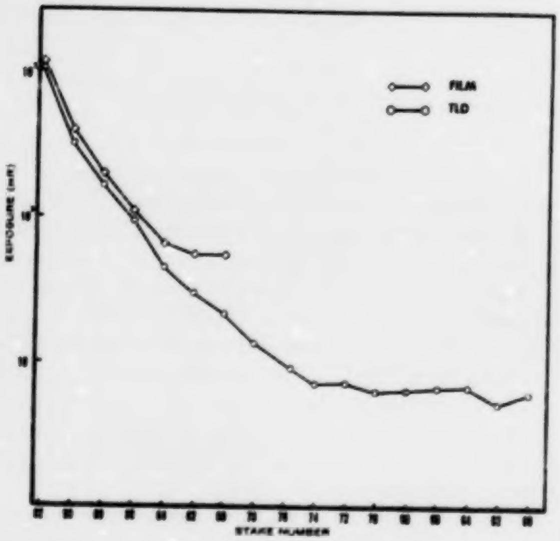

Figure 4. Cloud profile, Arc 1, Buggy 1, second pickup

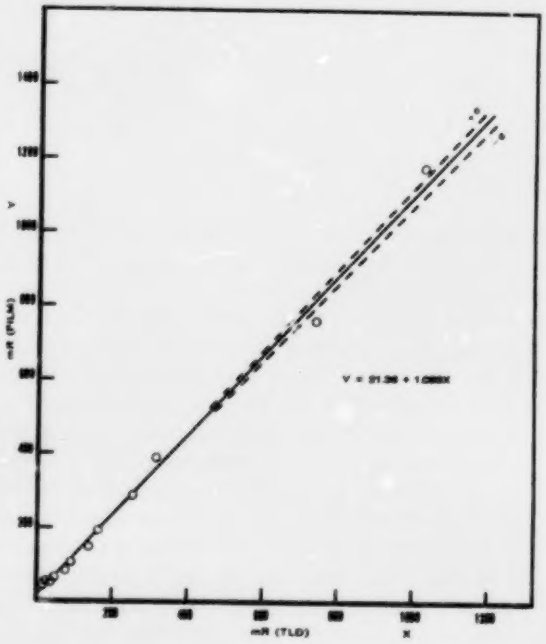

Figure 5. Correlation of film and TLD response from Arc 1, Buggy 1

b

Table 3. Paired thermoluminescent dosimeter-film badge data from Arc 1, Buggy 1.

Thermoluminescent dosimeters (mR)	Film badge (mR)
14.8	45
15.4	45
16.0	45
17.0	45
17.2	45
20.4	45
21.4	55
21.7	55
29.8	55
31.1	55
44.5	65
75.6	85
92.8	110
135.5	150
162.1	195
252.9	290
313.8	390
734.3	760
1,025.4	1,175

As can be seen from table 3, the film showed little sensitivity to small changes in exposures below 55 mR. A second linear regression analysis was performed on the lowest 13 data pairs. The result of the analysis (figure 6), yielded the relation, $y = 32.9 + 0.770x$. The slope of the regression line was equal to 0.770 with a coefficient of variation of 5.67 percent and a correlation coefficient of 0.98.

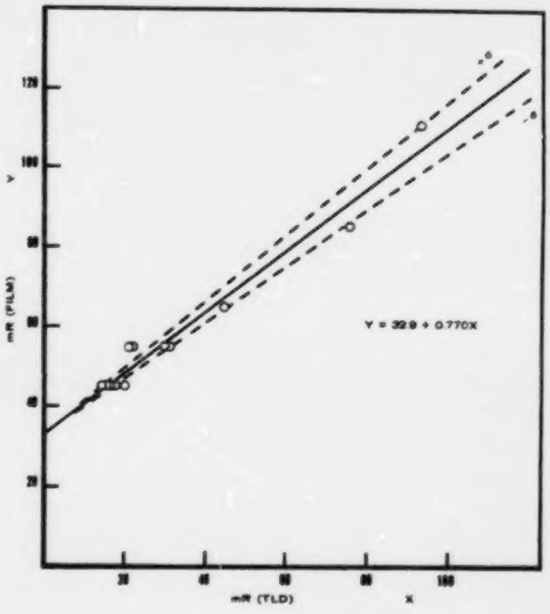

Figure 6. Correlation of film and TLD response from Arc 1, Buggy 1, lowest 13 data pairs

One DuPont type 545 film badge, the same type as is used in the dosimetry network, was placed on each stake along Arc 4, 51 miles from ground zero. Exposure profiles, as detected by both film badges and TLD's, are plotted in figure 7. The conspicuous lack of film badge data points results from the fact that exposure levels were near or below the minimum detectable limit of the film. Table 4 lists the paired values for which positive film data were available.

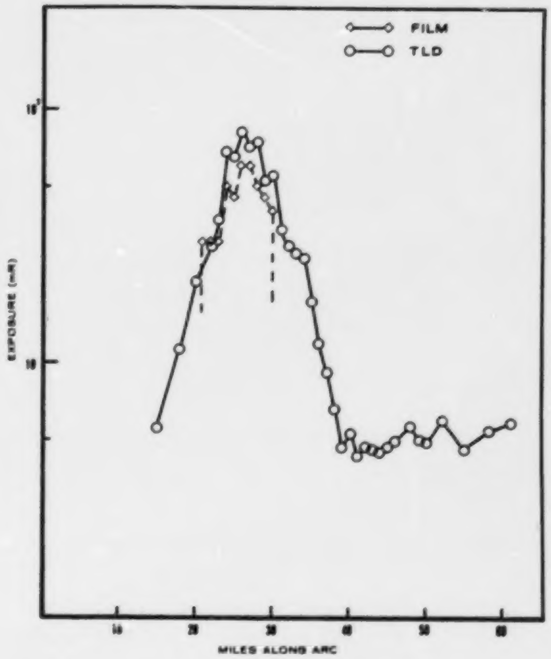

Figure 7. Cloud profile, Arc 4, Buggy 1

Table 4. Paired thermoluminescent dosimeter-film badge data from Arc 4, Buggy 1

Thermoluminescent dosimeters (mR)	Film badge (mR)
29.0	30
37.0	30
53.4	45
54.7	40
65.8	45
69.4	50
72.8	60
74.0	50
81.6	60

A linear regression on the data of table 4 yielded the relation, $y = 10.5 + 0.586x$, which is plotted in figure 8. The slope of the regression line was equal to 0.586 with a coefficient of variation of 4.37 percent and a correlation coefficient of 0.94.

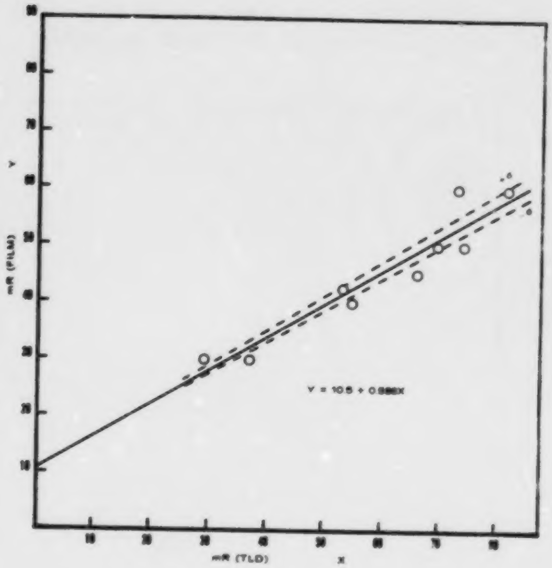

Figure 8. Correlation of film and TLD response from Arc 4, Buggy 1

The data in figures 5, 6, and 8, and their respective analyses are presented in the order of decreasing exposure levels. In general, as the level of exposures decreases, the correlation coefficient of film and TLD response decreases. The slope also decreases from unity, indicating that the range of exposure is near the minimum detectable limit of the film, i.e., there is a flattening of the curve at low exposures. An increasing degree of variation accompanies film response as exposure levels decrease, further indicating that the lower limit of detection is being approached. The above data would indicate that the lower detection limits of the 556 and 545 film are approximately 45 mR and 30 mR, respectively.

Discussion

It has been shown that the film badge as used by NERC–LV in the offsite environment is incapable of providing background information. During 1967, only 4 percent of the 6,454 badges issued had a reported value greater than zero. In addition, the data which were available varied from the expected exposures sufficiently that their validity was in doubt.

The Nuclear Engineering Company disposal site film badge data which escaped heat damage showed an excellent agreement with the TLD data. The high correlation is attributable to the ideal exposure range, 40–700 mR, for the film.

The same situation was seen in greater detail in the investigation of Plowshare data. Analyses of data resulting from three different levels of exposure indicated that as exposure levels decreased, the correlation coefficient of film and TLD response decreased. This is an indication that at lower exposures, TLD and film results are less likely to agree. It was evident that the lower exposures were approaching the minimum detectable limit of the film because the slope of the linear regressions decreased from unity with decreasing exposures.

A definite relationship between ambient temperatures and film damage has been shown in both the routine network data and Nuclear Engineering Company disposal site data. During 1967, 22 percent of the 6,454 film badges issued to routine stations were lost or damaged. The monthly damage percentage varied seasonally from a low of 1.8 percent in December to a high of 71.2- percent in July. Frequency of heat damage to film badges located at the Nuclear Engineering Company disposal site followed the same seasonal trend seen in the routine data. In 1967, 27 percent of the badges were heat damaged.

A statistical test of the Nuclear Engineering Company data indicated a possible seasonal effect on film response, in addition to the seasonal fluctuation of heat damage. This, and other research, tend to indicate that the precision of film response is less than that of the TLD.

The TLD is more suitable as an environmental monitor than the film badge and is quite

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capable of providing background information. In addition, it is unaffected by environmental heating both in terms of damage and response. Of 2,461 TLD's issued to routine stations, only 10 or 0.4 percent, failed to produce usable data. No data were missing from the 132 TLD's issued to the Nuclear Engineering Company disposal site during this same year.

In addition to the results of this investigation, there are several pieces of recent supporting research. According to Johnson and Attix (*2*), most erroneous film data, including readings which occur when no exposure exits, can be related to heat and humidity damage. They compared a quartz fiber dosimeter and two types of TLD's with film badges worn by personnel. The first three dosimeters agreed within 10 percent but the film badges were often in error by a factor of two or three.

From a processing standpoint, film is subject to more variables than the TLD. The accuracy and reproducibility of reported film badge exposures by commercial dosimetry services often are quite poor (*3*). The best accuracy appeared to be −50 to +200 percent. The film processing service at Mercury, Nev., used by NERC–LV is believed to be considerably better than this (±20 percent above 100 mR). This claim is supported by the good correlation of our film and TLD data in favorable exposure ranges.

Kathren (*4*) has shown that considerable fogging of dosimetry film occurs above 50°C, a condition often attained in the field situations under discussion. This high frequency of heat and light damage was one of the major reasons for investigating and acquiring a TLD system at NERC–LV.

Conclusions

The review of TLD and film badge data from the routine dosimetry stations, the Nuclear Engineering Company disposal site, and a Plowshare experiment, leads to conclusions which favor TLD's. The TLD is more sensitive to the exposures of interest than the film badge. Because of this, it has been possible to obtain average values for background exposure rates at the various dosimetry stations.

The high ambient temperatures encountered during the summer months cause an unacceptable amount of damage to film badges used as environmental monitors. In addition to heat damage, there is evidence that film sensitivity is temperature dependent, which may cause a seasonal effect on film badge results. TLD's at the same locations sustain no apparent effects from environmental heating.

Statistical treatment of dosimetry data shows the TLD to be more precise than the film. Typical TLD reproducibility is well within ±5 percent.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, June 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

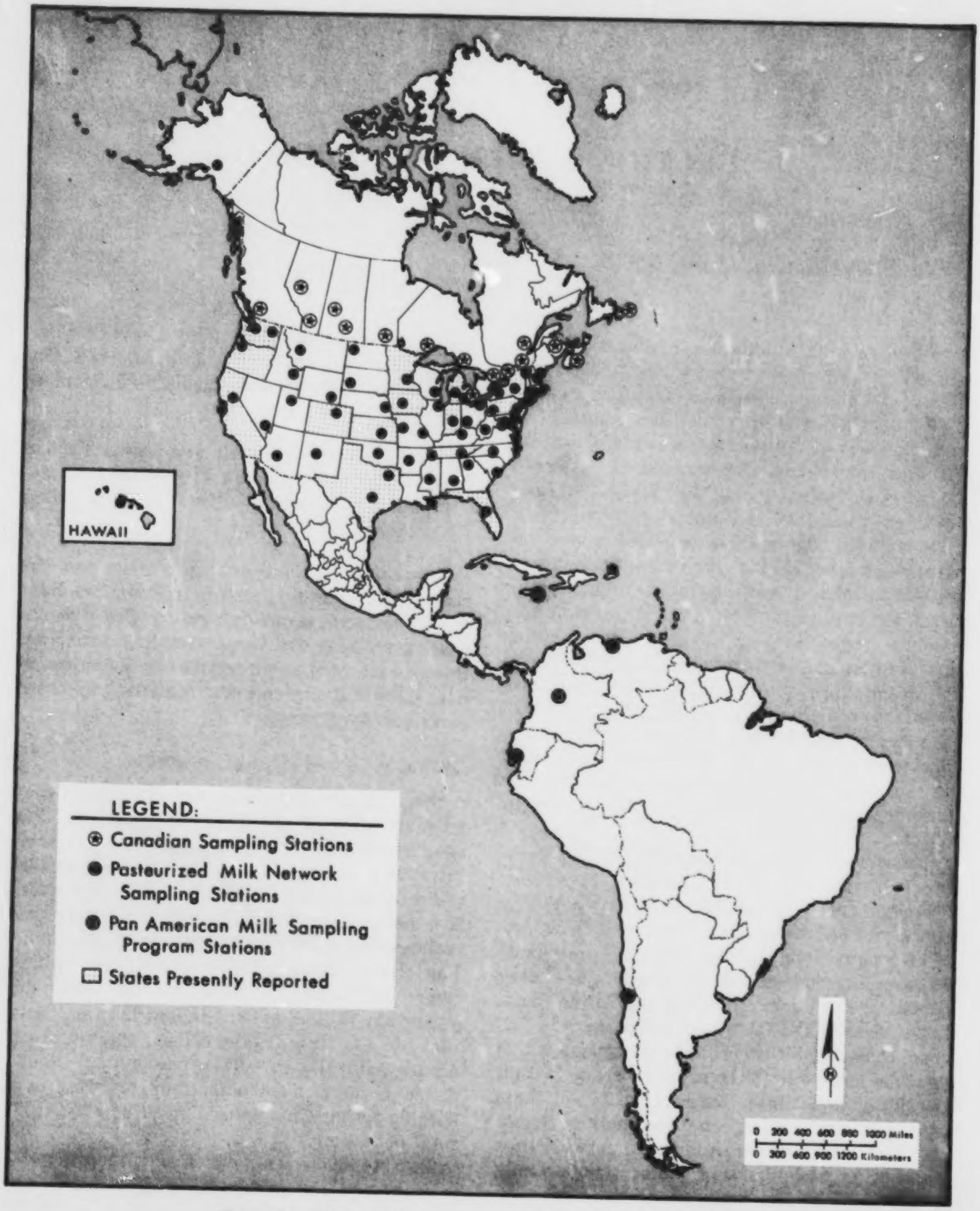
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conduct periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	8
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Table 2. Concentration of radionuclides in milk for June 1972 and 12-month period, July 1971 through June 1972

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	7	15	10
Alaska:	Palmer[c]	P	5	5	15	12
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	NA	12	13	10
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	3	0	0
	Del Norte	P	13	11	12	10
	Fresno	P	0	2	0	5
	Humboldt	P	3	3	0	7
	Los Angeles	P	0	2	0	5
	Mendocino	P	3	5	0	7
	Sacramento	P	2	2	0	6
	San Diego	P	0	1	0	5
	Santa Clara	P	0	1	0	7
	Shasta	P	2	3	0	8
	Sonoma	P	2	2	0	7
Colo:	Denver[c]	P	NA	5	0	5
	East	R	NA		[d]0 (2)	0
	Northeast	R	NA		[d]0 (8)	1
	Northwest	R	NS		NS	0
	South Central	R	NS		NS	
	Southeast	R	NA		[d]0	0
	Southwest	R	NA		[d]0	0
	West	R	NA		[d]0	5
Conn:	Hartford[c]	P	NA	6	0	8
	Central	P	7	7	16	14
Del:	Wilmington[c]	P	NA	8	15	5
D.C:	Washington[c]	P	NA	7	0	6
Fla:	Tampa[c]	P	4	5	33	40
	Central	R	4	6	49	39
	North	R	4	10	17	21
	Northeast	R	3	6	11	35
	Southeast	R	8	6	113	59
	Tampa Bay area	P	4	6	34	38
	West	R	6	10	20	19
Ga:	Atlanta[c]	P	NA	9	12	15
Hawaii:	Honolulu[c]	P	0	3	0	3
Idaho:	Idaho Falls[c]	P	4	5	0	0
Ill:	Chicago[c]	P	7	7	0	11
Ind:	Indianapolis[c]	P	NA	7	0	3
	Central	P	6	7	15	12
	Northeast	P	5	7	15	14
	Northwest	P	8	8	15	16
	Southeast	P	9	8	25	15
	Southwest	P	9	8	10	15
Iowa:	Des Moines[c]	P	NA	4	0	1
	Iowa City	P	6	6	10 (3)	10
	Des Moines	P	7	7	11	11
	Little Cedar	P	6	7	NS	11
	Spencer	P	NS	6	NS	11
Kans:	Wichita[c]	P	NA	8	0	2
	Coffeyville	P	8	8	0	13
	Dodge City	P	7	5	0	9
	Falls City, Nebr	P	NS		NS	
	Hays	P	9	10	0	9
	Kansas City	P	7	8	0	11
	Topeka	P	6	8	11	9
	Wichita	P	7	11	0	9
Ky:	Louisville[c]	P	NA	8	12	9
La:	New Orleans[c]	P	10	14	0	12
Maine:	Portland[c]	P	NA	7	22	21
Md:	Baltimore[c]	P	NA	8	0	5
Mass:	Boston[c]	P	6	7	14	11
Mich:	Detroit[c]	P	NA	7	13	11
	Grand Rapids[c]	P	NA	8	0	8
	Bay City	P	3	5	0	13
	Charlevoix	P	6	9	9 (5)	14
	Detroit	P	4	6	0	10
	Grand Rapids	P	3	5	16	9
	Lansing	P	6	7	0 (2)	14
	Marquette	P	5	7	23 (2)	24
	Monroe	P	0	3	14	5
	South Haven	P	3	5	8 (5)	9
Minn:	Minneapolis[c]	P	NA	8	14	16
	Bemidji	P	5	8	14	19
	Duluth	P	13	15	34	29
	Fergus Falls	P	8	8	12	17
	Little Falls	P	22	16	51	31
	Mankato	P	7	6	0	12
	Marshall	P	4	6	11	12

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for June 1972 and 12-month period, July 1971 through June 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Minn:	Minneapolis	P	10	12	17	17
	Rochester	P	7	7	11	14
Miss:	Jackson[e]	P	NA	12	14	10
Mo:	Kansas City[e]	P	NA	8	0	5
	St. Louis[e]	P	NA	5	0	4
Mont:	Helena[e]	P	NA	6	0	7
Nebr:	Omaha[e]	P	NA	7	0	3
Nev:	Las Vegas[e]	P	NA	2	0	1
N.H:	Manchester[e]	P	NA	8	23	18
N.J:	Trenton[e]	P	NA	7	0	6
N.Mex:	Albuquerque[e]	P	NA	3	0	0
N.Y:	Buffalo[e]	P	5	6	0	8
	New York City[e]	P	NA	7	0	9
	Syracuse[e]	P	NA	7	0	9
	Albany	P	6	6	[d]0 (5)	[d]0
	Buffalo	P	6	4	[d]0	[d]0
	Massena	P	9	7	[d]0 (2)	[d]0
	New York City	P	10	7	[d]0	[d]0
	Syracuse	P	6	5	[d]0	[d]0
N.C:	Charlotte[e]	P	NA	11	0	9
N. Dak:	Minot[e]	P	NA	9	0	14
Ohio:	Cincinnati[e]	P	NA	6	0	4
	Cleveland[e]	P	NA	7	0	7
Okla:	Oklahoma City[e]	P	NA	7	0	7
Oreg:	Portland[e]	P	4	5	0	4
	Baker	P	NA		[d]0	[d]0
	Coos Bay	P	NA		[d]0	[d]3
	Eugene	P	NA		[d]0	[d]1
	Medford	P	NA		[d]0	[d]4
	Portland composite	P	NA		[d]0	[d]7
	Portland local	P	NA		[d]0	[d]11
	Redmond	P	NA		[d]0	[d]0
	Tillamook	P	NA		17	[d]12
Pa:	Philadelphia[e]	P	NA	7	11	6
	Pittsburgh[e]	P	NA	10	0	6
	Dauphin	P	6	7	0	12
	Erie	P	4	7	0	12
	Philadelphia	P	7	5	16	13
	Pittsburgh	P	9	6	0	14
R.I:	Providence[e]	P	NA	8	15	11
S.C:	Charleston[e]	P	9	9	23	15
S.Dak:	Rapid City[e]	P	NA	6	0	7
Tenn:	Chattanooga[e]	P	NA	8	0	9
	Memphis[e]	P	NA	7	0	4
	Chattanooga	P	NA	10	17	12
	Clinton	R	NA	9	11 (2)	14
	Fayetteville	R	NA	9	14	6
	Kingston	R	NA	9	12 (2)	10
	Knoxville	P	NA	8	14 (2)	9
	Lawrenceburg	R	NA	8	0	0
	Nashville	P	NA	8	16	8
	Pulaski	R	NA	8	18 (2)	8
Tex:	Austin[e]	P	NA	1	0	0
	Dallas[e]	P	NA	6	0	1
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[e]	P	5	4	0	5
Vt:	Burlington[e]	P	NA	5	0	11
Va:	Norfolk[e]	P	NA	8	12	7
Wash:	Seattle[e]	P	NA	4	0	6
	Spokane[e]	P	NA	6	0	8
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	2
	Longview	R	7		0	
	Sandpoint, Idaho	R	13	12	0	20
	Skagit County	R	12	8	0	6
W. Va:	Charleston[e]	P	NA	8	14	5
Wisc:	Milwaukee[e]	P	NA	6	13	7
Wyo:	Laramie[e]	P	NA	8	0	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1972 and 12-month period, July 1971 through June 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:						
Alberta:	Calgary	P	7	7	14	18
	Edmonton	P	7	7	NA	
British Columbia:						
	Vancouver	P	8	9	30	25
Manitoba:						
	Winnipeg	P	6	7	14	22
New Brunswick:						
	Fredericton	P	12	12	15	20
Newfoundland:						
	St. John's	P	17	18	30	30
Nova Scotia:						
	Halifax	P	9	11	11	23
Ontario:	Ottawa	P	7	7	12	12
	Sault Ste. Marie	P	12	13	23	30
	Thunder Bay	P	10	12	18	25
	Toronto	P	3	4	10	12
	Windsor	P	4	4	6	9
Quebec:	Montreal	P	7	7	10	16
	Quebec	P	8	10	20	28
Saskatchewan:						
	Regina:	P	7	7	11	17
	Saskatoon	P	7	9	15	18
CENTRAL AND SOUTH AMERICA:						
Canal Zone:						
	Cristobal[c]	P	NA	0	16	7
Chile:	Santiago	P	0	0	0	2
Colombia:	Bogota	P	2	1	0	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Montego Bay	P	5	4	102	69
Puerto Rico:						
	San Juan[c]	P	NA	3	12	8
Venezuela:						
	Caracas	P	NS		NS	
PMN network average[e]			5	6	6	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0 was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[e] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12

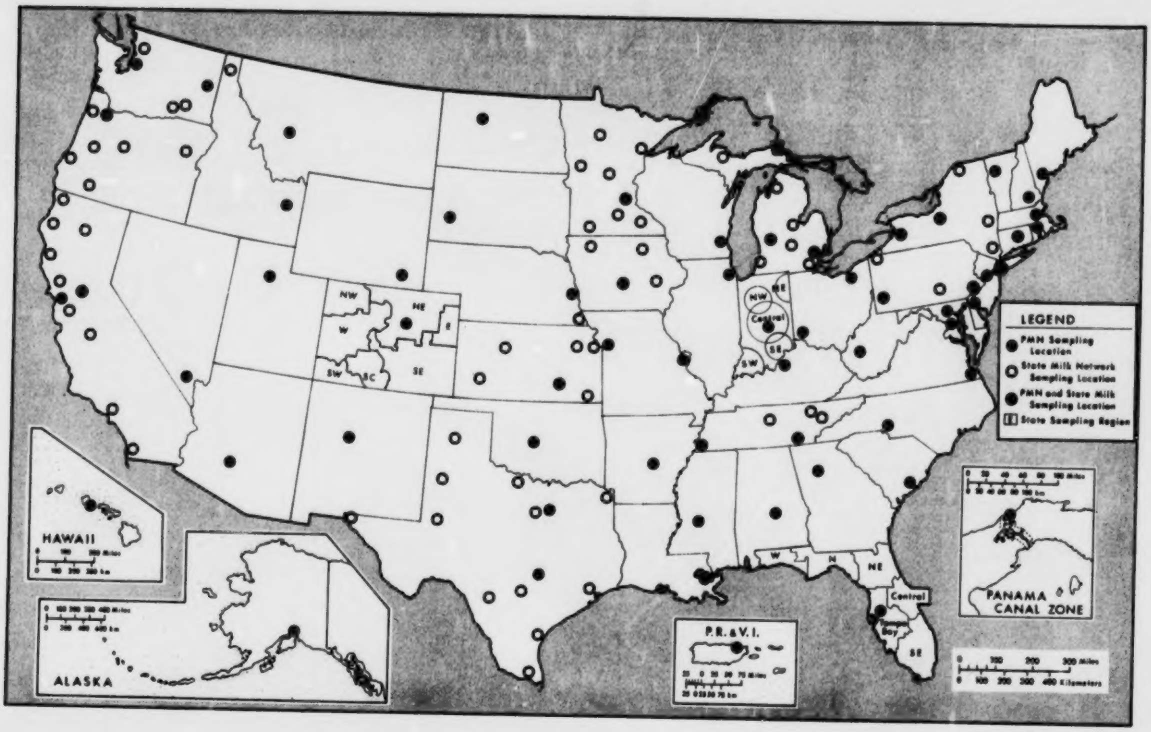
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for June 1972 and the 12-month period, July 1971 to June 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for June 1972 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Table 3. Strontium-89, iodine-131, and barium-140 in milk, June 1972

Sampling location		Concentration (pCi/liter)		
		Strontium-89	Iodine-131	Barium-140
Calif:	Del Norte (State)	10		
Kans:	Coffeyville (State)	6		
	Dodge City (State)	6		
	Hays (State)	5		
	Kansas City (State)	6		
	Topeka (State)	6	13	11
	Wichita (State)	9		
La:	New Orleans (PMN)	9		

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for June 1972, and the highest 12-month average was 16 pCi/liter (Little Falls, Minn.) representing 8.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 113 pCi/liter in the United States for June 1972, and the highest 12-month average was 59 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (7) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	July-December 1971	May 1972
Connecticut Standard Diet	January-December 1970	December 1971
Institutional Total Diet	October-December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January-December 1970	April 1972
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968-1970	September 1972
Radioactivity in California Waters	January-December 1970	June 1972
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, *HASL*	January-June 1971	April 1972
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January-March 1972	August 1972
Washington	July 1969-June 1970	March 1972

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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Gross Radioactivity in Surface Waters of the United States February 1972

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, it is intended to reinitiate this activity as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 12 rivers during February 1972. Table 2 presents additional gross radioactivity measurements collected from six river stations during October 1971. These data supplement the data previously pub-

Table 1. Gross radioactivity in U.S. surface waters, February 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Bear River:					
Idaho-Utah Line	1	1.7	4.2	5	12
Clinch River:					
Kingston, Tenn	[a]4	<0.4 (<0.3, 0.4)	<0.5 (<0.4-0.6)	<2 (<2, 2)	<4 (<3, 5)
Colorado River:					
DeBeque, Colo:	1	<.4	6.3	<2	14
Highway Bridge, Moab, Utah	3	1.4 (.5, 1.9)	7.8 (6.7, 9.7)	4 (2, 6)	15 (12, 19)
Millcreek above Moab, Utah	4	.9 (.8, 1.0)	10.1 (8.8, 11.9)	6 (4, 8)	18 (17, 20)
Silt, Colo	1	<.4	<1.7	4	11
Colorado-Utah Line	1	1.1	3.6	10	13
Dolores River:					
Bedrock, Colo	3	6.7 (1.7, 15.9)	8.1 (2.9, 11.4)	27 (7, 51)	19 (11, 28)
Gateway, Colo	4	1.7 (1.2, 2.1)	23.8 (16.7, 38.2)	6 (5, 8)	63 (57, 98)
Gunnison River:					
Grand Junction, Colo	1	.7	6.0	3	8
Mississippi River:					
Burlington, Iowa	1	1.4	2.3	5	5
Missouri River:					
St. Joseph, Mo	1	.6	4.8	3	13
St. Louis, Mo	1	1.2	4.8	3	15
Ohio River:					
Cincinnati, Ohio	4	1.8 (.5, 4.1)	<.7 (.6, .8)	6.8 (<2, 12)	7 (3, 17)
Roanoke River:					
John Kerr Dam, Va	4	.7 (.4, 1.0)	<.5 (<.4, .6)	<2 (<2, 3)	2 (2, 3)
San Miguel River:					
Naturita, Colo	4	1.5 (<.4, 2.4)	3.3 (1.9, 4.7)	4 (<2, 9)	7 (<5, 8)
Uravan, Colo	4	<.6 (<.4, 1.0)	3.8 (2.3, 7.7)	<3 (<2, 4)	<9 (<4, 13)
Below Uravan, Colo	4	1.0 (.4, 1.6)	27.4 (11.5, 34.2)	6 (<2, 9)	39 (21, 48)
St. Lawrence River:					
Massena, N.Y	3	<.4 (< .3, .4)	<1.0 (< .6-1.5)	<2 (<2, <2)	5 (4, 6)
Yampa River:					
Maybell, Colo	1	1.5	1.7	11	9

[a] Where more than one sample is analyzed during the month, the minimum and maximum are in parentheses.

Table 2. Gross radioactivity in U.S. surface waters, October 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Arkansas River:					
Ponca City, Okla	1	5.7	5.3	19	11
Mississippi River:					
Vicksburg, Miss	1	1.8	<0.4	6	4
West Memphis, Ark	1	.8	2.3	3	9
Red River:					
Dennison, Tex	1	.6	3.6	<2	8
Rio Grande:					
Brownsville, Tex	1	1.4	6.3	4	22
Laredo, Tex	1	2.3	4.4	5	10
Saline River:					
Ruliff, Tex	1	1.0	.7	4	6
Verdigris River:					
Nowata, Okla	1	1.5	<1.1	5	5

lished in *Radiation Data and Reports*, Volume 13, June 1972. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*), and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Radioactivity of Lake Michigan, August-September 1970

Office of Water Programs
U.S. Environmental Protection Agency

In accordance with recommendations of the Conferees of the Four-State Conference on Pollution of Lake Michigan and Its Tributary Basin (Illinois, Indiana, Michigan, and Wisconsin), a committee was appointed to develop specific recommendations for a coordinated Four-State-Federal monitoring program in the Lake Michigan Basin.

It was recommended by the Monitoring Committee that the Federal government monitor the open waters of Lake Michigan at specified stations, during the spring, summer, and fall of each year. At stations in unstratified areas, samples are to be collected at the surface, at mid-depth, and near the lake bottom. In stratified areas, samples are to be collected at the surface, just above and below the thermocline, and near the bottom.

The Region V Office of the Environmental Protection Agency is responsible for the overall conduct of the program. The radioactivity monitoring aspect of the program was initiated in August 1970, extending through September 1970. Water and sediment samples were collected and sent for radiochemical analyses to the Engineering and Sciences Branch of the

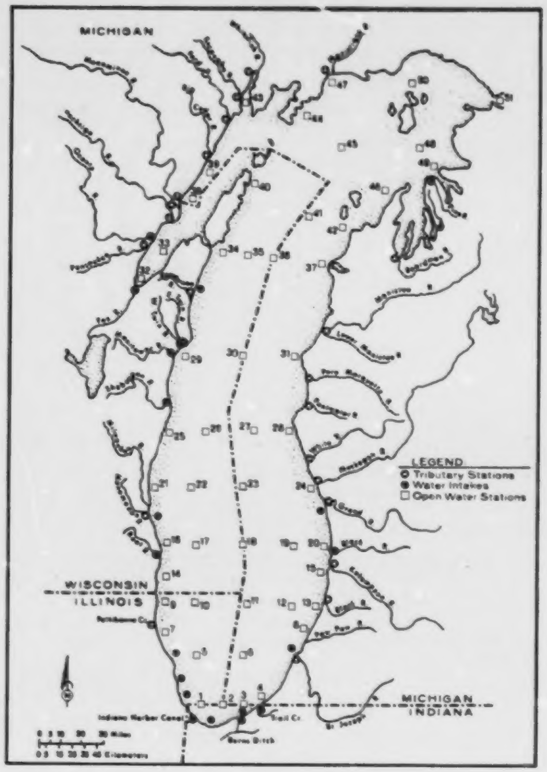

Figure 1. Lake Michigan basin monitoring stations

Table 1. Lake Michigan basin water monitoring stations

Station	Latitude	Longitude
1	41°46′00″	87°20′00″
2	41°46′00″	87°13′00″
3	41°46′00″	87°00′00″
4	41°48′00″	86°53′00″
5	42°00′00″	87°25′00″
6	42°00′00″	87°00′00″
7	42°12′00″	87°43′00″
8	42°14′00″	86°28′00″
9	42°24′00″	87°47′00″
10	42°23′00″	87°25′00″
11	42°23′00″	87°00′00″
12	42°23′00″	86°35′00″
13	42°23′00″	86°20′00″
14	42°37′00″	87°45′00″
15	42°37′00″	86°18′00″
16	42°47′00″	87°41′00″
17	42°44′00″	87°25′00″
18	42°44′00″	87°00′00″
19	42°44′00″	86°35′00″
20	42°44′00″	86°15′00″
21	43°08′00″	87°53′00″
22	43°08′00″	87°25′00″
23	43°08′00″	87°00′00″
24	43°08′00″	86°19′00″
25	43°36′00″	87°44′00″
26	43°36′00″	87°22′00″
27	43°36′00″	86°47′00″
28	43°36′00″	86°33′00″
29	44°05′00″	87°34′00″
30	44°05′00″	87°00′00″
31	44°05′00″	86°33′00″
32	44°35′35″	87°57′19″
33	44°50′20″	87°45′55″
34	44°47′00″	87°14′00″
35	44°45′00″	87°00′00″
36	44°43′00″	86°44′00″
37	44°30′00″	86°17′00″
38	45°05′00″	87°31′00″
39	45°23′30″	87°16′20″
40	45°14′00″	86°53′00″
41	45°02′00″	86°24′00″
42	44°56′00″	86°05′00″
43	45°45′38″	87°02′45″
44	45°34′00″	86°21′00″
45	45°32′00″	86°10′00″
46	45°13′00″	85°40′00″
47	45°56′00″	86°14′00″
48	45°31′00″	85°25′00″
49	45°21′00″	85°20′00″
50	45°53′00″	85°36′00″
51	45°48′00″	84°45′00″

Division of Applied Technology in Cincinnati, Ohio.

Sampling stations for radioactivity monitoring are shown in figure 1. Table 1 presents the specific latitude-longitude coordinates for these stations. Table 2 presents the gross alpha and gross beta measurements, tritium levels and solids concentration. Selected samples were composited using equal aliquots for strontium-90 and cesium-137 measurements. Table 3 presents these results. Table 4 presents the radioactivity data associated with the bottom sediments. In all cases, the error term is the counting error only and is expressed at the 1-sigma level. Radioactivity concentrations noted as "less than" are defined by NBS Handbook 86 (*1*). The data show the levels of radioactivity are very low and, in most cases, are less than the sensitivity of the analytical methods and counting equipment.

REFERENCE

(*1*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Table 2. Radioactivity in Lake Michigan water, August–September 1970

Station	Source	Date collected (1970)	Suspended solids			Dissolved solids			Tritium (nCi/liter)
			mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	
51	Surface	8/4	<0.1	<0.2	<1.8	132	<0.5	4.1±1.2	<0.4
51	Mid depth		.4	<.2	<1.8	144	<.5	<3.1	.9± .2
51	Bottom		5.7	<.3	<2.5	80	<.3	<1.8	.5± .2
50	Surface		<.1	<.2	<1.8	128	<.4	<2.4	<.4
50	Mid depth		.4	<.2	<1.6	124	<.4	<2.7	<.4
50	Bottom		.7	<.2	<1.8	108	<.4	<2.4	<.4
47	Surface	8/5	.5	<.2	<1.7	132	<.4	<2.3	<.4
47	Mid depth		.4	<.2	<1.6	104	<.4	<2.2	.8± .2
47	Bottom		.7	<.2	<1.8	124	<.4	<2.7	<.4
48	Surface		<.1	<.2	<1.6	144	<.5	<3.1	.5± .2
48	Above thermocline		.8	<.2	<1.7	120	<.4	<2.6	<.4
48	Below thermocline		.7	<.2	<1.8	112	<.4	<2.5	<.4
48	Bottom		1.9	<.2	<1.7	116	<.4	<2.5	<.4
44	Surface	8/6	<.1	<.2	<1.8	244	<.8	<5.3	.7± .2
44	Above thermocline		.2	<.2	<1.8	248	<.6	6.5±1.5	.6± .2
44	Below thermocline		.1	<.2	<2.2	248	<.6	5.3±1.5	<.4
44	Bottom		.2	<.2	<1.6	236	<.6	6.7±1.4	.5± .2
40	Surface	8/7	<.1	<.2	<1.7	80	<.2	2.7± .5	.9± .2
40	Mid depth		<.1	<.2	1.7	88	<.2	3.0± .5	.6± .2
40	Bottom		.4	<.2	<1.7	88	<.2	2.8± .5	.5± .2
34	Surface	8/8	<.1	<.2	<2.4	92	<.2	2.8± .5	.8± .2
34	Mid depth		.7	<.1	<1.1	132	<.3	2.5± .8	<.4
34	Bottom		.5	<.1	<1.1	124	<.3	3.4± .7	.5± .2
29	Surface		.2	<.1	<1.2	148	<.4	3.1± .9	.9± .2
29	Mid depth		.9	<.1	1.2± .5	128	<.3	4.6± .8	.7± .2
29	Bottom		.9	<.1	<1.1	140	<.3	4.6± .8	.6± .2
30	Surface	8/10	<.1	<.1	<1.2	124	<.3	4.1± .7	.8± .2
30	Above thermocline		.2	<.1	1.2	136	<.3	3.6± .8	.5± .2
30	Below thermocline		.2	<.1	<.8	128	<.3	3.4± .8	.4± .2
30	Bottom		.7	<.1	<1.2	164	<.4	4.2±1.0	.6± .2
31	Surface	8/11	.5	<.1	1.4± .4	160	<.4	5.0±1.0	<.4
31	Mid depth		.3	<.1	<1.3	168	<.4	<2.5	<.4
31	Bottom		.7	<.1	<1.2	136	<.3	2.8± .8	.6± .2
37	Surface	8/12	<.1	<.1	<1.2	140	<.3	3.1± .8	.5± .2
37	Above thermocline		<.1	<.1	<1.1	148	<.4	3.4± .9	<.4
37	Below thermocline		<.1	<.1	<1.1	144	<.4	<2.1	<.4
37	Bottom		.2	<.1	<1.2	144	<.3	3.8± .7	<.4
41	Surface		.9	<.1	<1.2	148	.4± .2	5.1± .7	6± .2
41	Above thermocline		<.1	<.1	<1.2	132	<.3	3.6± .6	<.4
41	Below thermocline		<.1	<.1	<1.2	132	<.3	1.7± .6	.5± .2
41	Bottom		<.1	<.1	<1.2	148	<.3	3.7± .7	.9± .2
42	Surface	8/13	.3	<.1	<.1	152	.3± .2	5.4± .7	.6± .1
42	Mid depth		.2	<.1	<.9	152	<.3	4.1± .7	<.3
42	Bottom		.4	<.1	<.9	160	.5± .2	4.6± .8	.4± .2
49	Surface		.2	<.1	<.9	136	<.3	3.5± .6	.8± .2
49	Above thermocline		.2	<.1	<1.0	144	<.3	4.1± .7	.6± .2
49	Below thermocline		.2	<.1	<.9	144	<.3	4.3± .7	.6± .2
49	Bottom		.7	<.1	<.9	160	<.3	2.5± .7	.6± .2
1	Surface	9/16	.5	<.1	<.7	160	<.3	3.7± .8	.4± .2
1	Mid depth		.1	<.1	<.7	164	<.3	3.9± .8	.8± .2
1	Bottom		<.1	<.1	<.7	268	<.5	5.9±1.3	.9± .2
3	Surface	9/17	<.1	<.1	<.8	204	<.4	6.1±1.2	.8± .2
3	Above thermocline		<.1	<.1	.8±.3	204	.6± .3	5.3±1.2	<.4
3	Bottom		<.1	<.1	<.9	192	<.4	3.9±1.1	<.4
4	Surface		<.1	<.1	<.8	184	<.4	5.4±1.0	.7± .2
4	Mid depth		<.1	<.1	<.9	164	.3± .2	3.9± .9	.8± .2
4	Bottom		9.3	<.1	<.8	184	<.4	3.9±1.0	.4± .2
5	Surface	9/16	.1	<.1	<.8	204	<.4	3.7±1.1	.6± .2
5	Above thermocline		<.1	<.1	<.9	196	<.4	3.8±1.1	<.4
5	Below thermocline		<.1	<.1	<.9	96	<.2	2.5± .8	.4± .2
5	Bottom		<.1	<.1	<.9	96	<.2	2.4± .8	<.4
2	Surface	9/16	4.3	<.1	<.8	100	<.2	2.4± .8	.7± .2
2	Mid depth		<.1	<.1	<.9	72	<.1	<1.5	.5± .2
2	Bottom		.1	<.1	<.1	128	<.2	<2.6	<.4
6	Surface	9/17	<.1	<.1	<1.2	148	<.2	<3.0	<.4
6	Above thermocline		<.1	<.1	<1.0	148	<.2	<3.0	<.4
6	Below thermocline		<.1	<.1	<1.0	160	<.3	3.7±1.3	<.4
6	Bottom		.2	<.1	<1.1	152	<.3	3.5±1.2	<.4
8	Surface		1.1	<.1	<2.3	148	<.3	<3.0	.6± .2
8	Below thermocline		.1	<.1	<1.1	148	<.3	<3.0	.4± .2
8	Bottom		.4	<.1	<1.1	88	<.2	2.0± .7	.5± .2
7	Surface	9/18	.1	<.1	<1.1	76	<.2	2.2± .6	<.4
7	Above thermocline		2.8	<.1	<1.7	124	<.3	<2.5	.5± .2
7	Bottom		1.8	<.1	<1.2	108	<.3	<2.2	<.4
9	Surface		1.0	<.1	<1.1	92	<.2	<1.9	<.4
9	Mid depth		.4	<.1	<1.1	312	<.7	<6.4	.7± .2
9	Bottom		.5	<.1	<1.1	276	<.6	<5.7	.6± .2
14	Surface	9/21	.4	<.1	<1.1	216	<.5	4.7±1.8	.7± .2
14	Mid depth		.6	<.1	<1.1	176	<.4	<3.6	.4± .2
14	Bottom		.6	<.1	<1.1	176	<.4	<3.6	<.4
16	Surface		.5	<.1	<2.1	456	<1.1	<9.4	.5± .2
16	Mid depth	9/21	.3	<.1	<1.1	124	.2± .1	3.2±1.0	.4± .2
16	Bottom		.4	<.1	1.2± .5	112	.2± .1	2.5±1.0	.6± .2
17	Surface		.5	<.1	1.3± .5	136	<.2	<2.9	<.4
17	Above thermocline		.4	<.1	<1.8	156	<.2	5.0±1.3	.8± .2
17	Below thermocline		.3	<.1	<1.2	160	<.2	3.9±1.4	.4± .2
17	Bottom		.2	<.1	<1.1	152	.3± .1	3.9±1.3	<.4

See footnotes at end of table.

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Table 2. Radioactivity in Lake Michigan water, August–September 1970—continued

Station	Source	Date collected (1970)	Suspended solids			Dissolved solids			Tritium (nCi/liter)
			mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	mg/liter	Alpha (pCi/liter)	Beta (pCi/liter)	
41	Surface	9/22	<.1	<.1	<1.2	108	.1± .1	<2.3	<.4
41	Above thermocline		<.1	<.1	<1.2	140	<.2	<3.0	<.4
41	Below thermocline		<.1	<.1	<1.1	100	<.1	2.6± .8	<.4
41	Bottom		72.4	.3±.1	6.8± .5	120	.2± .1	3.2±1.0	<.4
36	Surface		.1	<.1	<1.1	92	<.1	<1.9	<.4
36	Above thermocline		<.1	<.1	<1.2	92	<.1	2.1± .8	.7± .2
36	Below thermocline		<.1	<.1	<1.1	264	<.5	<5.6	<.4
36	Bottom		<.1	<.1	<1.1	272	.9± .3	<5.8	<.4
35	Surface		.1	<.1	<1.1	200	<.4	<4.2	<.4
35	Above thermocline		<.1	<.1	<1.2	204	<.4	<4.3	.5± .2
35	Below thermocline		<.1	<.1	<1.3	72	<.2	1.3± .4	<.4
35	Bottom		<.1	<.1	<1.2	92	<.2	2.0± .6	<.4
34	Surface	9/24	.2	<.1	<1.2	112	<.3	2.5± .7	<.4
34	Above thermocline		.4	<.1	<1.2	108	<.3	3.4± .7	<.4
34	Bottom		.5	<.1	<.9	172	<.4	4.7±1.0	.6± .2
39	Mid depth	9/23	.5	<.1	<.8	172	<.4	5.3±1.0	<.4
39	Bottom		.4	<.1	<.8	176	<.4	2.9±1.0	<.4
43	Surface		2.3	<.1	<.8	180	.6± .3	4.9±1.1	<.4
43	Mid depth		1.3	<.1	<.8	140	<.4	<2.1	<.4
43	Bottom		30.9	.4± .1	4.1± .3	144	<.4	4.7± .9	<.4
40	Surface	9/24	.7	<.1	<.8	132	<.3	3.3± .8	<.4
40	Below thermocline		.1	<.1	<1.0	132	<.3	4.4± .8	<.4
40	Bottom		.7	<.1	<.9	160	<.4	3.3±1.0	<.4
33	Surface	9/23	.7	<.1	<.8	236	<.6	3.9±1.4	.6± .2
33	Mid depth		.0	<.1	<.8	184	<.5	5.0±1.1	<.4
33	Bottom		48.8	.4± .1	4.5± .4	164	<.4	4.1±1.0	<.4
29	Surface	9/26	.6	<.1	<.9	148	<.4	4.9± .9	.4± .2
29	Above thermocline		.4	<.1	<.8	172	<.4	3.4±1.0	.6± .2
29	Bottom		.3	<.1	<.8	168	<.6	4.3±1.0	<.4
30	Surface		.4	<.2	<1.3	140	<.5	4.2± .9	.6± .2
30	Above thermocline		.5	<.1	<.8	124	<.4	2.0± .7	.5± .2
30	Below thermocline		.3	<.1	<.8	120	<.4	3.5± .7	.4± .2
30	Bottom		.4	<.1	<.8	116	<.4	3.9± .7	<.4
38	Surface	9/23	1.0	<.1	<.8	112	<.4	2.7± .7	<.4
38	Mid depth		.8	<.1	<.8	344	.6± .3	11.5±1.7	.8± .2
38	Bottom		.8	<.1	<1.0	376	<.5	14.4±1.9	.9± .2
25	Surface	9/27	.1	<.1	<.1	292	<.5	9.1±1.4	.4± .2
25	Above thermocline		.3	<.1	<.7	252	<.4	8.6±1.2	<.4
25	Bottom		.5	.6± .1	.9± .3	360	.7± .4	11.4±1.8	.9± .2
26	Surface		<.1	<.1	<.7	304	<.5	8.4±1.5	<.4
26	Above thermocline		.5	.1± .1	<.6	244	<.4	7.1±1.2	<.4
26	Below thermocline		<.1	<.1	<.7	212	.4± .2	6.4±1.0	<.4
26	Bottom		.4	<.1	<.7	176	<.3	3.7± .9	<.4
27	Surface		.3	<.1	<.7	164	<.3	2.9± .8	.6± .2
27	Above thermocline		.5	<.1	<.7	160	<.3	3.6± .8	<.4
27	Below thermocline		.7	<.1	<.7	188	<.3	3.7± .9	<.4
27	Bottom		17.3	.1± .1	1.0± .3	192	<.3	3.4± .9	<.4
28	Surface		.2	<.1	<.6	168	<.3	2.3± .8	<.4
28	Above thermocline		.6	<.1	<.7	152	<.3	2.5± .7	<.4
28	Bottom		1.0	<.1	<.7	148	.5± .2	3.9± .7	<.4

Table 3. Radioactivity of composited water samples

Composite	Station	Source	Concentration (pCi/liter)	
			Cesium-137	Strontium-90
A	51 51 51	Surface Mid depth Bottom	0.20±0.05	1.00±0.06
B	50 50 50 47 47 47	Surface Mid depth Bottom Surface Mid depth Bottom	.78± .14	1.5 ± .2
C	40 41 42 41 40	Surface	.10± .03	—
D	40 41 42 41 40	Mid depth Below thermocline Mid depth Below thermocline Below thermocline	<.03	.35± .05

Table 3. Radioactivity of composited water samples—continued

Composite	Station	Source	Concentration (pCi/liter)	
			Cesium-137	Strontium-90
E	40 41 42 41 40	Bottom	<.33	1.8 ± .2
F	34 37 36 35 34	Surface	<.42	1.2 ± .2
G	34 37 36 35 34	Mid depth Below thermocline Below thermocline Below thermocline Above thermocline	.53±.14	1.1 ± .1
H	36 35 34	Bottom	.41±.08	1.2 ± .1
J	29 30 31 29 30	Surface	.20± .04	.80± .08
K	29 30 31 29 30	Above thermocline Below thermocline Mid depth Above thermocline Below thermocline	<.28	2.8 ± .3
L	29 30 31 29 30	Bottom	<.30	1.4 ± .2
M	25 26 27 28	Surface	.30± .07	—
N	25 26 27 28	Above thermocline Below thermocline Below thermocline Above thermocline	<.25	—
O	25 26 27 28	Bottom	.22± .06	—
P	5 6	Surface	<.50	1.3 ± .2
Q	5 6	Below thermocline	<.33	—
S	1 3 4 2	Surface	.73±.10	.9 ±.1
T	1 3 4 2	Mid depth Above thermocline Mid depth Mid depth	.5 ± .1	1.5 ± .1
U	1 3 4 2	Bottom	.24± .05	1.4 ± .1
V	33 38	Surface	<.36	1.9 ± .2
W	39 33 38	Mid depth	.31± .08	1.1 ± .1
X	39 33 38	Bottom	.51± .14	1.2 ± .1
Y	49 49 49	Surface Below thermocline Bottom	.54± .06	.67± .06

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Table 4. Radioactivity in Lake Michigan sediments, August–September 1970

Station number	Date collected (1970)	Gross alpha (pCi/g dry weight)	Gross beta (pCi/g dry weight)	[a]K$^+$ (mg/g)	Natural uranium (μg/g)	Natural thorium (μg/g)	Radium-226 (pCi/g dry weight)
51	8/4	2	15	10.0	<0.1	<2	0.22
50		<1	14	8.9	<.1	<2	.24
47	8/5	<1	17	18.0	<.1	<2	.14
48		6	52	22.0	.4	2	.88
44	8/6	10	37	11.6	<.1	<2	.99
34	8/8	<1	<10	8.2	<.1	<2	.10
29		2	15	12.5	<.1	<2	.44
30	8/10	5	26	19.5	<.1	<2	.77
31	8/11	2	20	15.5	<.1	<2	<.05
37	8/12	9	38	22.0	<.1	<2	1.30
41		3	28	23.5	<.1	<2	1.23
49	8/13	3	17	11.0	<.1	<2	.43
3	9/17	3	25	12.5	.2	<2	.55
4		3	18	12.0	.1	<2	.29
5	9/16	4	33	10.9	<.1	<2	.29
6	9/17	7	37	15.5	.3	<2	.85
8		2	16	10.2	<.1	<2	.45
9	9/21	7	31	10.5	.1	<2	.29

[a] Potassium-40 contribution can be calculated by multiplying mg/g by 0.84 pCi/mg K$^+$.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican Air Monitoring Program	January-April 1972	September 1972
Plutonium in Airborne Particulates	October-December 1971	July 1972
Surface Air Sampling Program; 80th Meridian Network, *HASL*	January-December 1969	February 1972

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1. Radiation Alert Network
June 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1972.

All other field estimates reported were within normal limits for the reporting station.

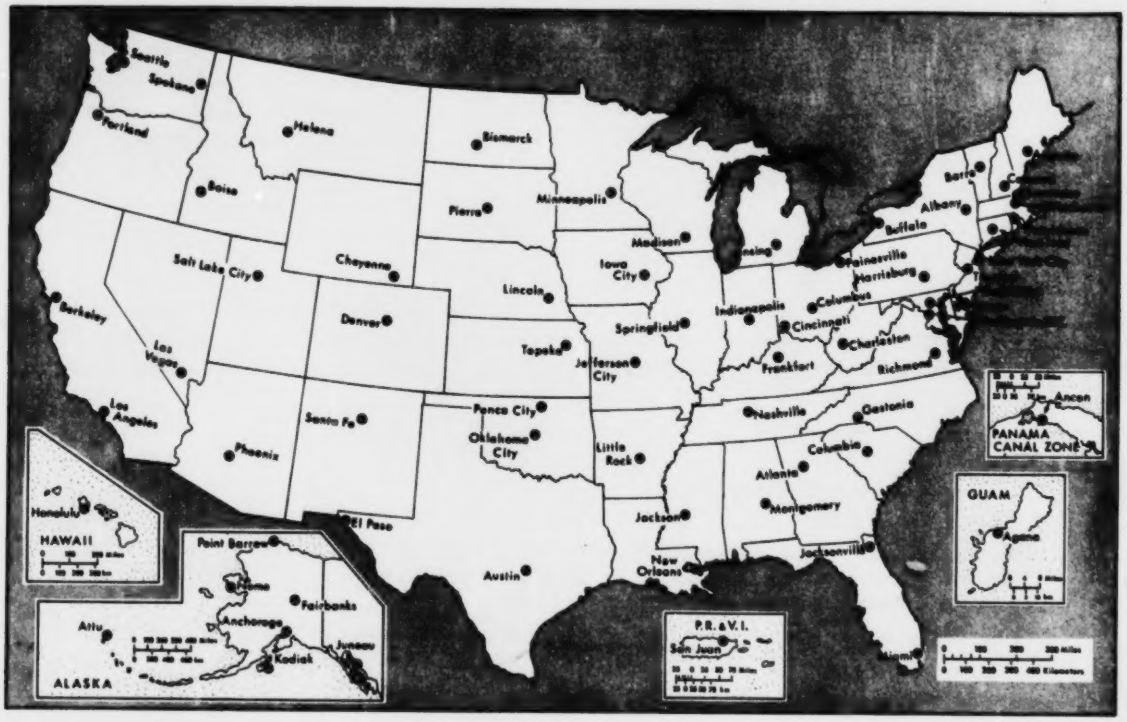
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Madison
Lansing
Buffalo
Albany
Barre
Painesville
Harrisburg
Iowa City
Lincoln
Berkeley
Denver
Indianapolis
Columbus
Cincinnati
Springfield
Topeka
Charleston
Las Vegas
Jefferson City
Frankfort
Richmond
Los Angeles
Ponca City
Nashville
Gastonia
Santa Fe
Oklahoma City
Phoenix
Little Rock
Columbia
Atlanta
Honolulu
HAWAII
Montgomery
El Paso
Jackson
Point Barrow
Jacksonville
Nome
Fairbanks
New Orleans
Austin
Anchorage
Attu
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Miami
Ancon
PANAMA CANAL ZONE
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1972

Station location	Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
		Maximum	Minimum	Average[a]	Number of samples	Total depth (mm)	Field estimation of deposition		
							Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	19	2	0	1	3	41	3	41	25
Alaska: Anchorage	3	0	0	0	0				
Attu Island	22	0	0	0	0				
Fairbanks	0				0				
Juneau	0				0				
Kodiak	0				0				
Nome	0				0				
Point Barrow	0				0				
Ariz: Phoenix	19	7	1	3	0				
Ark: Little Rock	20	3	0	1	0				
Calif: Berkeley	20	1	0	0	1	7	1	7	0
Los Angeles	21	1	0	1	0				
C.Z: Ancon	17	0	0	0	0				
Colo: Denver	21	6	1	2	4	79	[b]		
Conn: Hartford	21	1	0	0	12	201	12	201	0
Del: Dover	22	1	0	0	0				
D.C: Washington	24	1	0	0	0				
Fla: Jacksonville	22	1	0	0	6	102	6	102	20
Miami	0				0				
Ga: Atlanta	19	2	1	1	0				
Gaum: Agana	0				0				
Hawaii: Honolulu	17	1	0	0	2	15	[b]		
Idaho: Boise	20	2	0	1	1	11	1	11	7
Ill: Springfield	9	5	1	2	0				
Ind: Indianapolis	20	2	0	1	0				
Iowa: Iowa City	22	4	1	1	7	105	7	105	0
Kans: Topeka	22	6	1	2	3	30	3	30	0
Ky: Frankfort	8	3	1	1	0				
La: New Orleans	18	0	0	0	4	7	[b]		
Maine: Augusta	20	5	0	1	8	129	8	129	0
Md: Baltimore	21	1	0	0	7	68	6	60	0
Mass: Lawrence	21	1	0	0	7	162	7	162	0
Winchester	19	1	0	0	8	195	8	195	0
Mich: Lansing	22	1	0	1	7	74	7	74	3
Minn: Minneapolis	22	3	0	1	5	81	5	81	12
Miss: Jackson	15	2	0	1	4	45	4	45	2
Mo: Jefferson City	21	3	1	2	3	35	3	35	0
Mont: Helena	18	2	0	1	3	28	3	28	0
Nebr: Lincoln	16	8	0	3	2	42	2	42	4
Nev: Las Vegas	20	8	1	2	0				
N.H: Concord	0				0				
N.J: Trenton	21	1	0	0	12	189	12	189	8
N. Mex: Santa Fe	18	3	1	1	0				
N.Y: Albany	19	1	0	0	0				
Buffalo	20	2	0	1	0				
New York City	0				0				
N.C: Gastonia	18	8	0	3	2	33	[b]		
N. Dak: Bismarck	20	5	1	2	3	34	3	34	2
Ohio Cincinnati	0				0				
Columbus	5	2	1	1	0				
Painesville	20	1	0	0	12	187	12	187	31
Okla: Oklahoma City	3	4	1	2	0				
Ponca City	21	8	0	2	4	65	4	65	0
Oreg: Portland	18	1	0	0	3	10	3	10	3
Pa: Harrisburg	14	2	0	1	4	44	4	44	14
P.R: San Juan	0				0				
R.I: Providence	22	1	0	0	0				
S.C: Columbia	16	3	0	1	2	109	2	109	0
S. Dak: Pierre	22	6	0	2	0				
Tenn: Nashville	22	2	0	1	7	47	7	47	2
Tex: Austin	20	6	1	4	2	26	[b]		
El Paso	21	4	0	1	0				
Utah: Salt Lake City	28	2	0	1	1	2	1	2	1
Vt: Barre	16	2	0	1	7	80	7	80	8
Va: Richmond	18	1	0	0	1	21	1	21	10
Wash: Seattle	9	0	0	0	5	49	[b]		
Spokane	18	2	0	1	0				
W. Va: Charleston	21	3	0	1	13	91	13	91	13
Wisc: Madison	20	2	0	1	5	28	5	28	8
Wyo: Cheyenne	20	7	1	3	1	9	1	9	4
Network summary	1,094	8	0	1	181	82	5	73	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program, June 1972[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for June 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.2	0.0	0.1	16	2.3
Coral Harbour	4	.1	.0	.0	13	1.1
Edmonton	4	.2	.1	.1	44	5.0
Ft. Churchill	4	.1	.0	.1	80	6.7
Fredericton	4	.1	.0	.1	48	5.9
Goose Bay	4	.1	.1	.1	31	3.5
Halifax	25	.3	.1	.1	44	5.1
Inuvik	4	.1	.0	.1	106	4.4
Montreal	4	.1	.0	.1	42	5.6
Moosonee	4	.1	.1	.1	160	3.3
Ottawa	4	.2	.1	.1	43	5.7
Quebec	4	.1	.1	.1	51	5.9
Regina	4	.2	.1	.1	154	7.2
Resolute	4	.0	.0	.0	203	1.9
St. John's, Nfld	4	.1	.1	.1	41	4.0
Saskatoon	4	.2	.1	.1	97	5.6
Sault Ste. Marie	2	.1	.1	.1	157	4.7
Thunder Bay	4	.1	.1	.1	62	4.5
Toronto	4	.1	.1	.1	23	2.0
Vancouver	4	.1	.0	.1	79	3.7
Whitehorse	4	.2	.1	.1	57	2.0
Windsor	4	.2	.1	.2	104	7.0
Winnipeg	4	.2	.0	.1	122	6.1
Yellowknife	3	.1	.0	.1	NS	NS
Network summary	114	0.3	0.0	0.1	77	4.5

NS, no sample.

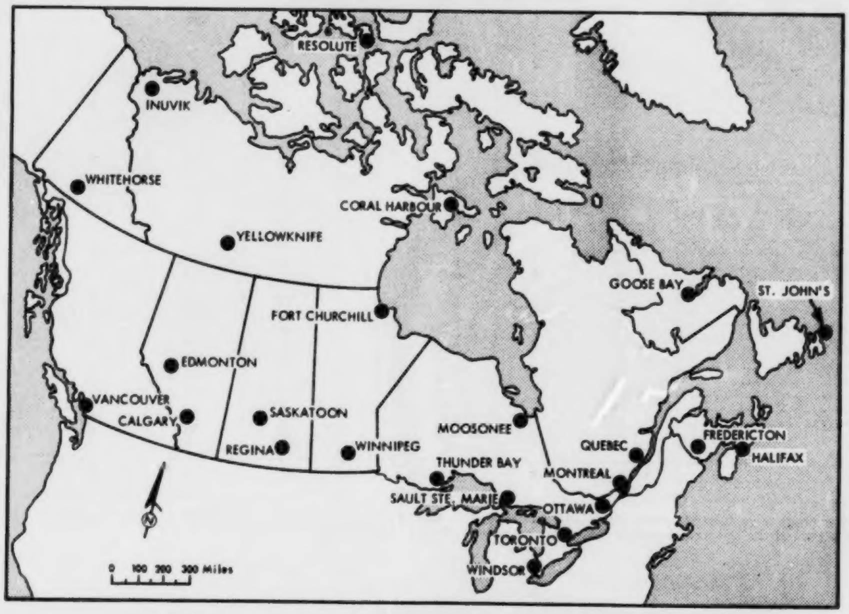
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program, June 1972

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The June 1972 air monitoring results from the participating countries are given in table 3.

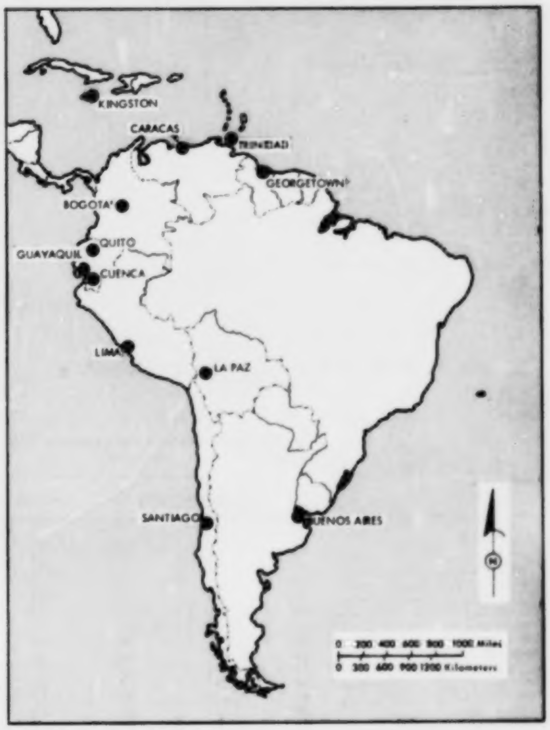

Figure 3. Pan American Air Sampling Program

Table 3. Summary of gross beta radioactivity in Pan American surface air, June 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average*
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	1	0.03	0.03	0.03
Chile:	Santiago	28	.12	.01	.04
Colombia:	Bogota	18	.04	.00	.01
Ecuador:	Cuenca	7	.03	.00	.01
	Guayaquil	10	.05	.01	.03
	Quito	16	.01	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	14	.07	.00	.03
West Indies:	Trinidad	11	.14	.04	.08
Pan American summary		105	0.14	0.00	0.03

*The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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4. California Air Sampling Program June 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations, operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continu-

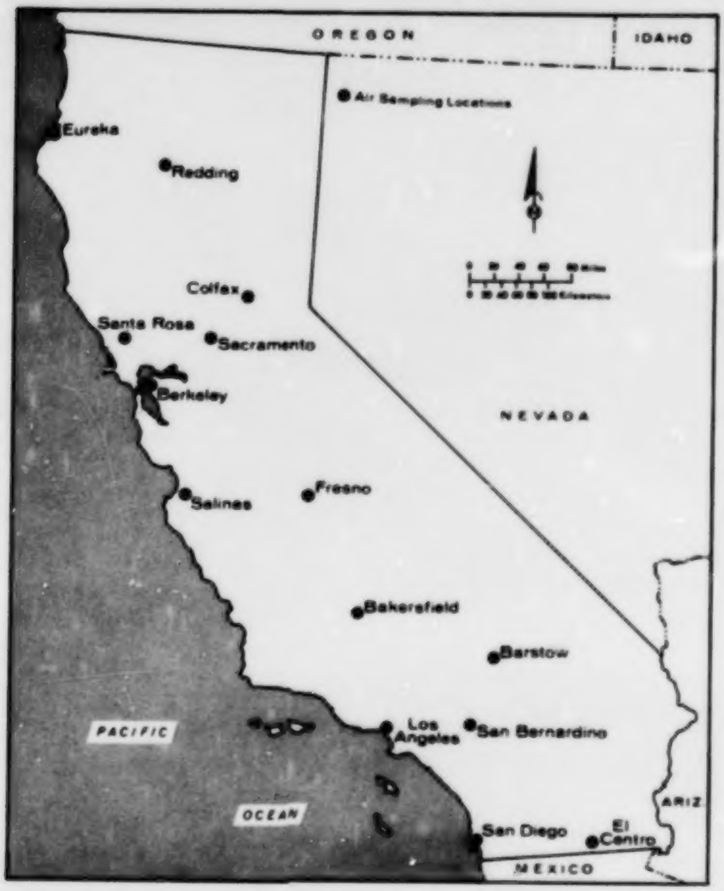
OREGON
IDAHO
● Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 4. California air sampling program stations

ous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for June 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air June 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	29	0.97	0.14	0.44
Barstow	30	.84	.25	.54
Berkeley	28	.43	.01	.14
Colfax	30	.85	.15	.42
El Centro	30	1.25	.25	.58
Eureka	26	.19	.00	.09
Fresno	30	1.15	.04	.47
Los Angeles	30	.60	.08	.25
Redding	21	.86	.28	.41
Sacramento	30	.73	.12	.29
Salinas	30	.47	.08	.21
San Bernardino	30	.89	.12	.37
San Diego	29	.42	.06	.26
Santa Rosa	30	.64	.04	.21
Summary	846	1.25,	0.00	0.33

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REFERENCES

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Air Surveillance Network, June 1972

National Environmental Research Center-Las Vegas, Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV),[1] consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station which lies within the NTS, and by the AEC at any other designated testing sites.[2]

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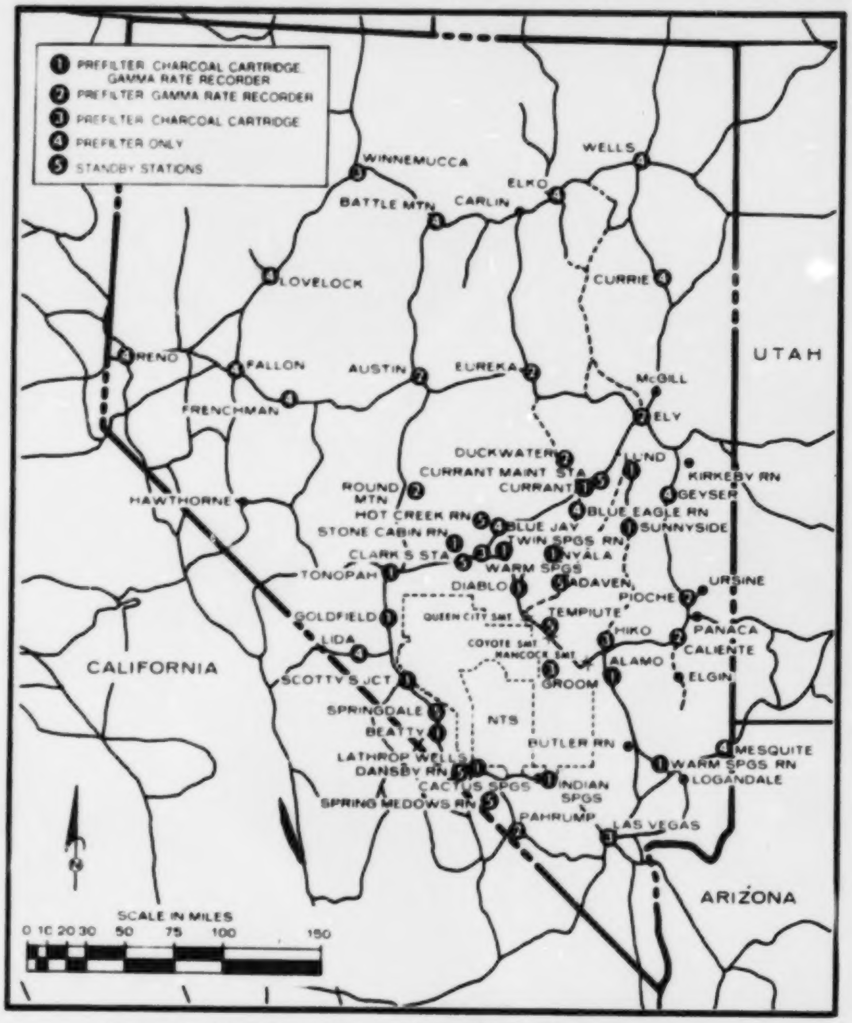
[1] Formerly the Western Environmental Research Laboratory (WERL).

[2] The ASN is operated under a Memorandum of Understanding (No. AT926-1-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.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② PREFILTER GAMMA RATE RECORDER
③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
WINNEMUCCA
WELLS
ELKO
BATTLE MTN
CARLIN
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
UTAH
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT STA
KIRKEBY RN
CURRANT
ROUND MTN
GEYSER
HAWTHORNE
BLUE EAGLE RN
HOT CREEK RN
BLUE JAY
SUNNYSIDE
STONE CABIN RN
TWIN SPGS RN
CLARK S STA
NYALA
WARM SPGS
TONOPAH
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PIOCHE
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MESQUITE
LATHROP WELLS
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DANSBY RN
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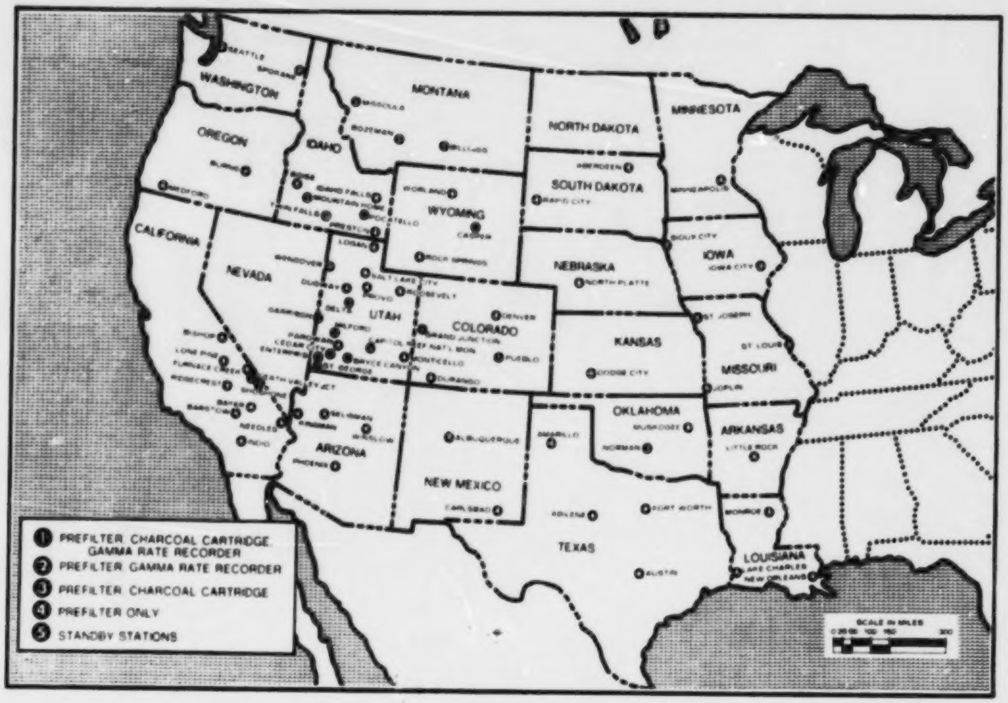
Figure 1. NERC-LV Air Surveillance Network stations in Nevada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OKLAHOMA
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① PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
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④ PREFILTER ONLY
⑤ STANDBY STATIONS

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

The stations are operated by State health department personnel and by private individuals on a contract basis. Daily 24-hour samples are collected at each station. All samples are mailed to the NERC–LV unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates for each of the network stations. The minimum reported concentration for gross beta is 0.1 pCi/m^3; however, gross beta concentrations above the minimum detectable concentration of 0.06 pCi/m^3 are used in determining averages. Individual concentrations which are below the minimum detectable concentration are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reported level are reported as <0.1 pCi/m^3. The highest gross beta concentration within the network on a single filter during June was 1.4 pCi/m^3 at Currie, Nev.

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Table 1. Summary of gross beta radioactivity concentrations in air, June 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Ariz:	Kingman	30	1.0	0.2	0.4
	Phoenix	27	.5	.1	.3
	Seligman	30	.5	<.1	.3
	Winslow	30	.4	.1	.3
Ark:	Little Rock:	22	.5	<.1	.3
Calif:	Baker	29	.7	.1	.3
	Barstow	29	.6	.2	.4
	Bishop	30	1.3	<.1	.5
	Death Valley Junction	25	.8	.2	.5
	Furnace Creek	30	.8	<.1	.4
	Indio	30	.6	.1	.3
	Long Pine	30	.8	.2	.4
	Needles	26	.6	.2	.4
	Ridgecrest	28	.7	<.1	.4
	Shoshone	30	.7	.2	.4
Colo:	Denver	22	.6	.1	.3
	Durango	30	.8	<.1	.4
Idaho:	Boise	30	.6	<.1	.6
	Idaho Falls	22	.8	.2	.4
	Preston	30	.7	.2	.4
	Twin Falls	30	.6	.1	.4
Iowa:	Iowa City	22	.9	<.1	.3
	Sioux City	25	.5	<.1	.4
Kans:	Dodge City	30	.4	<.1	.3
La:	Lake Charles	21	.7	<.1	.2
	Monroe	23	.6	<.1	.2
	New Orleans	20	.6	<.1	.2
Minn:	Minneapolis	21	.4	<.1	.2
Mo:	Joplin	25	.5	<.1	.3
	St. Joseph	30	.7	.2	.4
	St. Louis	30	.6	.1	.4
Nebr:	North Platte	25	.5	.2	.3
Nev:	Alamo	30	.6	.1	.4
	Austin	23	.8	<.1	.4
	Battle Mountain	30	.7	.1	.4
	Beatty	30	.8	.1	.4
	Blue Eagle Ranch (Currant)	23	.7	.3	.4
	Blue Jay	30	.7	.2	.4
	Caliente	29	.7	.1	.4
	Currant Ranch	30	.9	.2	.4
	Currie	30	1.4	.1	.4
	Diablo	30	.7	.1	.4
	Duckwater	23	.8	.1	.4
	Elko	30	.7	<.1	.4
	Ely	27	.6	<.1	.3
	Eureka	30	.8	.2	.4
	Fallini's Twin Springs Ranch	30	.8	.2	.5
	Fallon	30	.6	.2	.5
	Frenchman Station	30	.6	.2	.4
	Geyser Maintenance Station	29	.8	<.1	.4
	Goldfield	29	.7	.2	.4
	Groom Lake	26	.8	.2	.4
	Hiko	30	1.3	<.1	.4
	Indian Springs	24	.7	<.1	.3
	Las Vegas	21	.7	<.1	.4
	Lathrop Wells	30	.7	.1	.4
	Lida	28	.7	.2	.4
	Lovelock	30	.9	.1	.4
	Lund	30	.6	<.1	.3
	Mesquite	30	.7	.2	.4
	Nyala	30	.9	<.1	.5
	Pahrump	18	.6	<.1	.3
	Pioche	28	.5	.2	.3
	Reno	30	.7	.2	.4
	Round Mountain	28	.8	.2	.4
	Scotty's Junction	29	.9	.2	.5
	Stone Cabin Ranch	30	.8	<.1	.4
	Sunnyside	28	.9	.2	.4
	Tonopah	30	.7	<.1	.4
	Tonopah Test Range	23	.7	.2	.4
	Warm Springs	28	.9	.2	.4
	Warm Springs Ranch	23	.7	<.1	.4
	Wells	30	1.0	.1	.4
	Winnemucca	30	.7	<.1	.4
New Mex:	Albuquerque	22	.6	<.1	.3
	Carlsbad	29	.5	<.1	.3
Okla:	Muskogee	30	.5	<.1	.3
Oreg:	Burns	30	.5	.1	.3
	Medford	23	.5	<.1	.2
S. Dak:	Aberdeen	30	.6	<.1	.3
	Rapid City	30	.7	<.1	.3
Tex:	Abilene	29	.5	<.1	.2
	Amarillo	30	.6	<.1	.3
	Austin	22	<.7	<.1	.2
	Fort Worth	30	.6	<.1	.3

See footnotes at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, June 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Utah:	Bryce Canyon	27	.7	.1	.3
	Cedar City	29	.7	.1	.4
	Delta	28	.7	.1	.4
	Dugway	30	.9	<.1	.4
	Enterprise	30	.6	<.1	.4
	Garrison	30	.9	.1	.4
	Logan	29	.7	<.1	.4
	Milford	30	.8	<.1	.4
	Monticello	19	.7	<.1	.4
	Parowan	28	.8	.1	.4
	Provo	29	.8	.1	.4
	Roosevelt	30	.6	.1	.3
	Salt Lake City	29	.6	.1	.4
	St. George	30	.7	.1	.4
	Wendover	30	.7	<.1	.4
Wash:	Seattle	22	.8	<.1	.1
	Spokane	21	.5	.1	.2
Wyo:	Rock Springs	30	.7	<.1	.4
	Worland	30	.7	<.1	.3

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reporting value of 0.1 pCi/m³ is reported as <0.1.

From gamma spectrometry results, zirconium-95 and ruthenium-103, in varying combinations, were identified on filters collected in California, Missouri, and Nevada. The highest concentrations of these radionuclides, respectively, were 0.3 pCi/m³ (Death Valley Junction, Blue Jay, Groom Lake, and Tonopah Test Range), and 0.1 pCi/m³ (Austin, Nev.). These radionuclides are attributed to worldwide fallout.

Copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC–LV upon written request.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site, July-December 1969[1]

National Environmental Research Center-
Las Vegas,[2] *and*
Nevada Operations Office, AEC

Under a Memorandum of Understanding with the U.S. Atomic Energy Commission, the Southwestern Radiological Health Laboratory (SWRHL) conducted its continuing program of radiological surveillance, including monitoring and environmental sampling in the public areas surrounding the Nevada Test Site (NTS) from July through December 1969. During this period, 15 announced underground nuclear tests were conducted at the NTS and two other events were conducted, Project Milrow in Alaska and Project Rulison in Colorado. One of the NTS tests, the Pod Event, released radioactivity that was detected offsite. In addition, one power run of the XE-Prime nuclear rocket engine conducted at the Nuclear Rocket Development Station (NRDS) released radioactive material to the offsite environment.

Operational procedures

Comprehensive ground monitoring capabilities were maintained throughout this period. Mobile ground monitoring teams were positioned in offsite areas prior to each event. Each monitor was equipped with an Eberline E-500B survey meter, a Baird-Atomic Model NE-148 Scintillator, and a Victoreen Radector, Model No. AGB-50B-Sr. Eberline RM-11 gamma-rate recorders were also utilized to document cloud passage at fixed ground locations. Aerial monitoring capabilities included two SWRHL cloud sampling aircraft and an Air Force U-3A aircraft with an Air Force pilot and two SWRHL monitors equipped with portable instruments identical to those of the ground monitoring teams.

Immediately after each release of radioactivity, this aerial monitoring team tracked the cloud, determined its relative radiation intensity, and reported its position, speed and direction to assist in the positioning of ground monitors. The SWRHL aircraft also aided in cloud tracking and collected samples in the cloud to assess the total radionuclide inventory of the release.

The SWRHL Air Surveillance Network (ASN) consisted of 103 stations operating in every State west of the Mississippi River except Montana and North Dakota (figure 1). Fifteen stations were added in Colorado in support of Project Rulison and 18 were added in Alaska in support of Project Milrow. The air sampler used was a Gelman "Tempest" which was equipped to use a 4-inch-diameter Whatman 541 filter paper and an MSA charcoal cartridge.

The routine milk sampling program was continued during the 6-month period during which 194 samples were collected from both commercial dairies and private producers. Including both potable and nonpotable supplies, 564 water samples were collected from about 95 sources.

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[1] This article is a summary of report No. SWRHL-98r, "Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from July through December 1969."

[2] Formerly Southwestern Radiological Health Laboratory, U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health.

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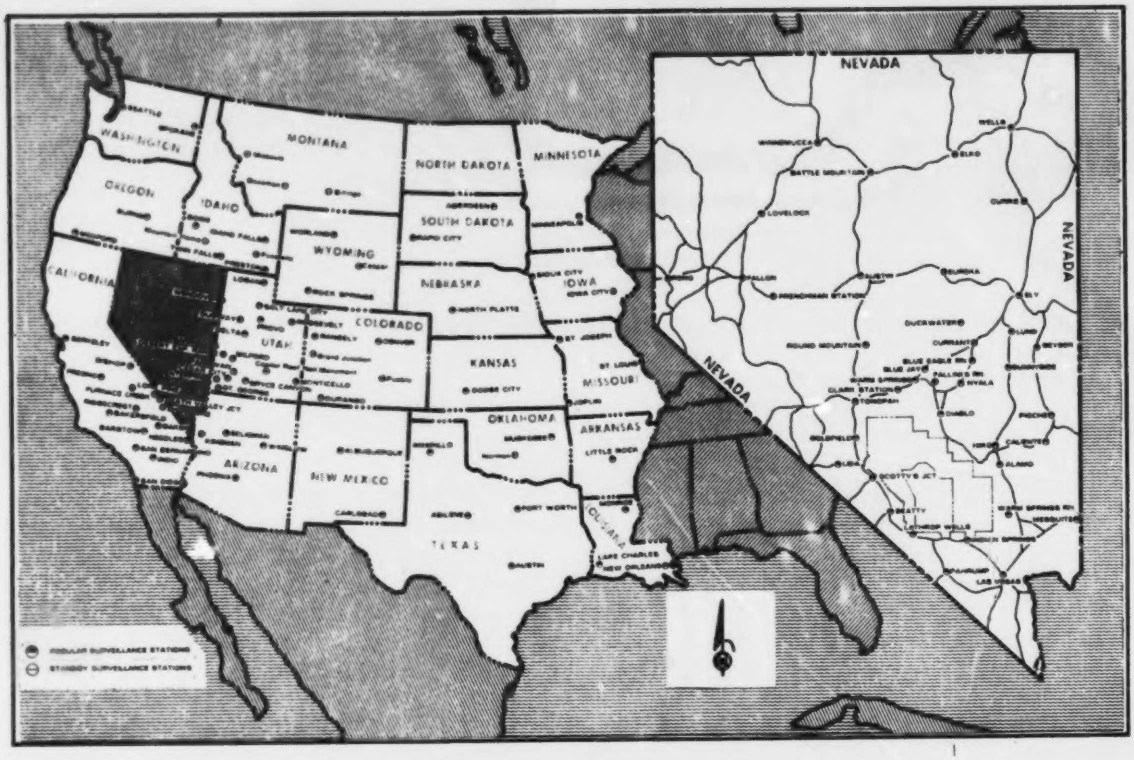
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UTAH
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
REGULAR SURVEILLANCE STATIONS
STANDBY SURVEILLANCE STATIONS

Figure 1. NERC-LV Air Surveillance Network stations

Vegetation samples, collected to delineate any fallout pattern, consisted of milk-cow feed samples taken at most locations where special milk samples were collected following known releases of radioactivity and natural vegetation samples collected along highways crossed by the cloud.

Approximately 87 residents in the offsite area wore film badges throughout this period. These film badges used DuPont type 545 film which records gamma exposures to an accuracy of ±50 percent in the 30 to 100 mR range and ±10 percent in the 100 to 2,000 mR range. In addition, 107 film badge stations, each with five film badges, were located around the NTS. Each station was also equipped with three EG&G Model TL–12 thermoluminescent dosimeters (TLD's).

A SWRHL medical officer was available to investigate reports of injuries alleged to be the result of the test series and to maintain liaison with local physicians. No injuries were reported. Veterinarian services were also provided by the SWRHL to conduct wildlife and domestic livestock investigations. Other community relations services included personal contact with offsite residents by route monitors and information presentations conducted at schools and civic centers. As a result, many offsite residents participated in the sampling program. All routine air sampling stations, except those in Las Vegas, were operated by local citizens.

Considerable additional coverage was provided in support of Project Milrow on Amchitka Island, Alaska, and for Project Rulison in Colorado. This effort consisted of pre- and postshot environmental sampling, the establishment of supplementary air surveillance networks and community information programs and, in the case of Rulison, preshot evacuation of local residents because of expected ground motion.

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Table 1. Five highest iodine-131 results and associated gross beta and isotopic results from air sample media extrapolated to end of collection period (combined particulate and charcoal filter), XE–Prime, EP IXA, August 28, 1969

Location azimuth-distance from experimental test site-1	Time on off	Date on off (1969)	Average concentrations during collection period and integrated concentrations											
			Gross beta		Iodine-131		Tellurium-132		Iodine-133		Iodine-135		Strontium-91	
			$\frac{\text{pCi}}{\text{m}^3}$	$\frac{\mu\text{Ci-s}}{\text{m}^3}$	$\frac{\text{pCi}}{\text{m}^3}$	$\frac{\mu\text{Ci-s}}{\text{m}^3}$	$\frac{\text{pCi}}{\text{m}^3}$	$\frac{\mu\text{Ci-s}}{\text{m}^3}$	$\frac{\text{pCi}}{\text{m}^3}$	$\frac{\mu\text{Ci-s}}{\text{m}^3}$	$\frac{\text{pCi}}{\text{m}^3}$	$\frac{\mu\text{Ci-s}}{\text{m}^3}$	$\frac{\text{pCi}}{\text{m}^3}$	$\frac{\mu\text{Ci-s}}{\text{m}^3}$
Koyne's Mill, Nev.[a] 28°, 55 miles	1854 2054	8/28 8/28	5,000	36	62	0.45	150	1.1	280	2.0	560	4.1	120	0.86
Queen City Summit, Nev.[a] 8°, 67 miles	1925 2050	8/28 8/28	5,700	29	55	.28	170	.86	320	1.6	550	2.8	190	.96
Nyala, Nev. 18°, 103 miles	[b]0700 0700	8/28 8/29	11	.85	1.7	.13	3.0	.23	5.5	.42	ND	ND	ND	ND
Blue Eagle Ranch, Nev.[c] 19°, 123 miles	[d]0655 0620	8/28 8/29	11	.81	1.3	.10	2.9	.22	ND	ND	ND	ND	ND	ND
Lund, Nev. 27°, 158 miles	0758 0814	8/28 8/29	9.6	.84	.9	.08	2.1	.18	ND	ND	ND	ND	ND	ND

[a] Temporary station.
[b] Sampler operated for 21.4 hours during this period.
[c] No charcoal cartridge run.
[d] Sampler operated for 21.3 hours during this period.
ND, nondetectable.

Analytical procedures

Samples were returned to the SWRHL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman Widebeta low-background, proportional counter system. Selected particulate filters, all charcoal cartridges, and water and milk samples were analyzed for gamma emitting isotopes; a 4- by 4-inch NaI(Tl) crystal coupled to a TMC model 404C gamma pulse height analyzer was used. The lower limit of detection for gamma emitters in air samples was 0.1 pCi/m^3 for a 10-minute counting time and a sample volume of 350 m^3/day. The lower limit of detection for gamma-emitters in 3.5-liter water and milk samples was 10 to 20 pCi/liter, depending on the counting time of 20 to 40 minutes. Gamma spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides.

Results

One of the underground tests during this period, the Pod Event conducted October 29, released radioactivity that was detected offsite. The maximum gross gamma exposure rate from this event was 0.06 mR/h, observed by ground monitors on GM survey instruments at Lathrop Wells and on Highway 95, 10 miles west of Highway Junction 95/16. Net exposure at both locations was less than 0.1 mR. No radiation above background was detected by gamma-rate recorders and no fresh fission products were found in milk, water or vegetation samples.

Experimental Plan IXA of the XE-Prime rocket engine test released radioactive effluent that was detected on seven ASN station air samplers and on three of the temporary samplers placed on highway 25 between Hancock Summit and Queen City Summit (table 1). Monitors detected cloud passage at Queen City Summit, Koyne's Mill and Coyote Summit. The peak radiation level was 0.04 mR/h on GM survey instruments. No radiation levels above background were measured by gamma-rate recorders and no fresh fission products were found in milk, water or cow feed samples. No dosimetry devices indicated exposures above background.

Conclusions

Results obtained through environmental radiation surveillance during the period July-December 1969 indicate that no individual in the offsite area received an exposure, resulting from NTS nuclear test activities, which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for the Knolls Atomic Power Laboratory and the Rocky Flats Plant.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2]
January–December 1969

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission (AEC), is to support the Naval Reactors Program of the AEC in the development of atomic power reactors for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors. The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the Kesselring site, located as shown in figure 1.

Knolls site

The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings.

The Knolls site releases small amounts of radioactive materials both to the atmosphere and to the Mohawk River. Prior to the release, exhaust air and liquid waste are treated and carefully monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted both on- and offsite at the Knolls site for the following purposes: 1) to audit the operational control of radioactive waste release to the environment, and 2) to ascertain compliance with the radioactivity standards established by the AEC.

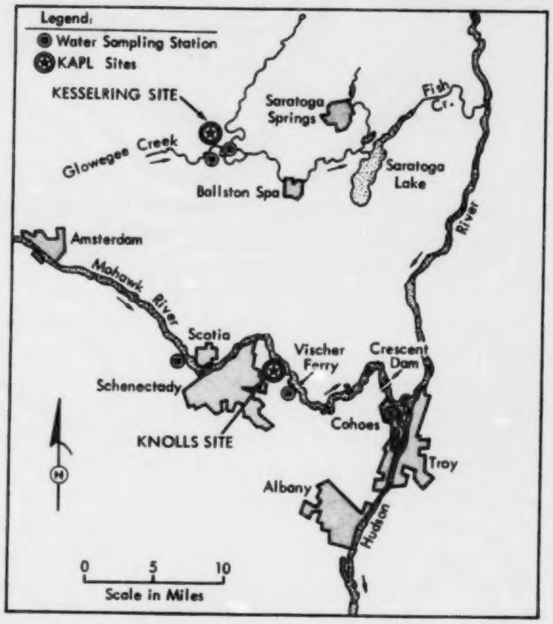

Figure 1. Environmental monitoring locations, KAPL

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[2] Summarized from "Knolls Atomic Power Laboratory, Knolls Site and Kesselring Site, Annual Environmental Monitoring Report, January–December 1969."

Air monitoring

Prior to the fourth quarter 1969, environmental airborne radioactivity was continuously sampled and analyzed on a weekly basis at two locations at the Knolls site and at the General Electric Company Research and Development Center, approximately 1 mile west of the Knolls site. This program was terminated after the third quarter since airborne radioactivity discharges are monitored at the point of discharge and portable air sampling equipment is available to measure radioactivity in the event of an accidental release of activity. In addition, instack radioactivity concentrations at the Knolls site average less than the appropriate concentration guides given in AEC Manual Chapter 0524.

For the first three calendar quarters of 1969, average beta-gamma concentrations in air were 100 fCi/m^3 and 110 fCi/m^3 at the Knolls and offsite sampling locations, respectively. The results were all less than the most restrictive environmental concentration guide for airborne beta-gamma emitting radionuclides given in AEC Manual Chapter 0524.

In addition to the environmental airborne radioactivity monitoring, surveys are made routinely of the radiation levels at the perimeter of the Knolls site facilities. The surveys of 1969 showed normal background radiation levels for the geographic location. The results of the surveys extrapolated to an annual exposure, indicate average radiation levels of < 0.1 R/a.

Liquid waste monitoring

All sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The collected waste water is processed and sampled and the samples analyzed to verify that the radioactivity concentration and the total activity content of the processed waste are within established discharge limits. Subsequently, the processed waste water is discharged to the Mohawk River at a controlled rate. During discharge, samples are again collected and composite samples are analyzed on a monthly basis.

A continuous proportional sample of the Knolls site combined sewer effluent is collected at the point of release to the Mohawk River. The radioactivity concentration in the effluent is continuously monitored and recorded by passing a portion of the sample through an in-line, lead shielded gamma scintillation detection system. An aliquot of the collected sample is analyzed whenever an increase in the gamma count rate above the normal range of background fluctuations is observed on the recorder.

A total of 22.5 millicuries of beta-gamma and 5.0 millicuries of alpha activity was discharged to the Mohawk River during 1969. The annual average concentration of strontium-90, which comprised 32 percent of the total beta-gamma activity in the effluent, was 4.8 pCi/liter or 1.6 percent of its environmental standard as given in AEC Manual Chapter 0524. The annual average concentration for the uranium isotopes, which comprised 98.8 percent of the total alpha activity, was 3.3 pCi/liter which is less than 0.1 percent of their effective environmental concentration guide.

Water monitoring

Mohawk River water is sampled continuously at the General Electric Company powerhouse 8 miles upstream from the Knolls site, and at the Vischer Ferry powerhouse 1.7 miles downstream. The weekly water samples are composited and analyzed for radioactivity on a monthly basis.

Due to the lack of any statistical differences in the radioactivity concentrations in upstream and downstream water samples, during periods when the radioactivity discharges to the Mohawk River were higher by factors of 4,000

Table 1. Radioactivity in Mohawk River water near the Knolls site, 1969

Sampling period (1969)	Beta and gamma radioactivity[a] (pCi/liter)			
	G.E. Powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes raw water (downstream)	Municipal water
January-March	<5.1	6	7	<5.1
April-June	<5.1	<5.1	<5.1	<5.1
July-September	7	7	NS	NS
October-December	<5.1	14	NS	NS

[a] Minimum detectable concentration, 90-percent confidence level: 5.1 pCi/liter. Concentration detectable at 90-percent confidence level with ± 30 percent precision: 19 pCi/liter.

NS, no sample, program terminated effective July 1, 1969.

or more than the annual discharge limit now in effect, the Cohoes water sampling program was discontinued effective the third quarter of 1969.

The average beta-gamma concentrations in Mohawk River water samples for each calendar quarter of 1969 are shown in table 1. The quarterly average concentrations were all significantly less than the most restrictive environmental concentration guide for strontium-90 given in AEC Manual Chapter 0524.

Sediment monitoring

The Mohawk River sediment monitoring program at the Knolls site consists of the collection and analyses of Mohawk River sediment in each of three calendar quarters; ice coverage prevents collection during the first calendar quarter. Samples are collected at 15 specific locations and all are analyzed for gamma, gross beta and alpha radioactivity. In addition, three of the samples are analyzed for strontium-90.

The average radioactivity concentrations in the quarterly samples of Mohawk River sediment for 1969 are given in table 2. The results indicate that the Knolls site radioactive liquid waste disposal program did not significantly influence the current radioactivity levels of the river sediment. In two of the three quarters, the sample location yielding the highest result was the location directly downstream from the Knolls site sewer outfall to the river. General concentrations rapidly diminished with increased distances from the sewer outfall.

Mohawk River fish radioactivity

Prior to 1969, samples of Mohawk River fish had been collected on an annual basis. A review of the monitoring data indicated no statistically significant difference between results obtained during periods of high radioactivity releases and recent periods in which releases were smaller by factors of 4,000 or more. On the basis of these results and the present low levels of annual discharge, the fish sampling program was terminated, effective 1969.

Kesselring site

The Kesselring site, located on approximately 4,000 acres near West Milton, N.Y., is a part of the Knolls Atomic Power Laboratory. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

During the first two quarters of 1969, environmental airborne radioactivity was continuously sampled and analyzed on a semiweekly basis at one location on the Kesselring site. This program was terminated after two quarters since airborne radioactivity discharges are monitored at the point of discharge and port-

Table 2. Radioactivity concentrations in Mohawk River sediment, KAPL, 1969 [a]

Sampling period (1969)	Number of samples	Total radioactivity (pCi/g dry weight)				Strontium-90 (pCi/g dry weight)		Cesium-137 (pCi/g dry weight)	
		Alpha		Beta					
		Average	Range	Average	Range	Average	Range	Average	Range
January-March	[b]NS								
April-June	15	0.63	0.2–0.9	48	20–90	<0.84	<0.84	4.66	0.5–10.3
July-September	15	.35	<.15–.8	50	34–83	<.84	<.84	1.1	.5– 4.9
October-December	15	.38	<.15–.6	30	14–51	<.84	<.84–.9	.86	.4– 3.0

[a] Minimum detectable concentration for a 600 g sample of 90-percent confidence level: alpha—0.15 pCi/g; beta—6.7 pCi/g; strontium-90—0.84 pCi/g and cesium-137—0.26 pCi/g. Concentration for 600 g sample detectable at 90-percent confidence level with 30 percent precision: alpha—0.85 pCi/g; beta—25 pCi/g; strontium-90—3.0 pCi/g, and cesium-137—0.94 pCi/g. The variation in the detectable levels is the result of differences in the size of sediment aliquots analyzed; i.e., alpha analysis, 10 g; beta analysis, 1 g; strontium-90, 10 g; cesium-137, total sample. Each sediment sample represents a surface area of 230 cm^2.

[b] Samples not collected due to ice on the Mohawk River.

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able air sampling equipment is available to measure radioactivity in the event of an accidental release of activity. The average long-lived beta-gamma concentration in the environmental air was 0.26 pCi/m^3 during the first two quarters. In-stack radioactivity concentrations averaged less than the appropriate concentration guides given in the AEC Manual Chapter 0524 for the second two quarters.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the Kesselring site perimeter. Perimeter surveys performed during the year showed normal background radiation levels for the geographic location. The result of the perimeter survey extrapolated to an annual exposure indicates average perimeter radiation levels of <0.1 R/a.

Radioactive liquid waste disposal

The liquid waste from the Kesselring site is collected, processed, and sampled prior to release to the Glowegee Creek. The radioactive waste discharged to the Glowegee Creek in terms of total radioactivity in liquid wastes was 3.4 millicuries for 1969. Radiochemical analyses of these wastes indicated that strontium-89 and strontium-90 concentrations were less than 1 percent of the respective AEC standards for this reporting period. The average result for unidentified radionuclides in the D1G and S3G effluents (9.8 and 56 pCi/liter) represent less than 1 percent and less than 2 percent, respectively, of the applicable AEC standard (3 nCi/liter).

Water monitoring

Samples of the Glowegee Creek water are analyzed for radioactivity once each quarter year at two locations. One is about 150 feet above the point where the S3G effluent enters the creek and the other is about 1,500 feet below the D1G effluent discharge point.

The average concentrations of beta and gamma radioactivity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid-waste outfalls are shown in table 3. All but one Glowegee Creek water analysis results were below 50 pCi/liter which is the measured concentration that may be considered valid at the 90-percent confidence level with a maximum error of 30 percent.

Table 3. Radioactivity in Glowegee Creek water from the Kesserling site operations, KAPL, January–December 1969

1969	Average beta and gamma concentrations (pCi/liter)	
	Glowegee Creek (upstream)	Glowegee Creek (downstream)
January-March	<50	<50
April-June	<50	<50
July-September	<50	111
October-December	<50	<50
Calendar year total	<50	<65

Sediment monitoring

Glowegee Creek sediment radioactivity measurements are analyzed on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The sediment analysis results are shown in table 4.

Table 4. Radioactivity in Glowegee Creek sediment, KAPL, January–December 1969

1969	Location	Number of samples	Gross-gamma radioactivity (pCi/g dry weight)		Cobalt-60 (pCi/g dry weight)
			Average	Range	
January–March	Upstream	NS			
	Downstream	1	9.8		1.20
April–June	Upstream	*2	9.1	7.5–10.7	1.35
	Downstream	*2	14.5	14.0–15.0	1.25
July–September	Upstream	3	12.8	9.9–18.0	1.46
	Downstream	3	15.2	10.7–18.6	2.66
October–December	Upstream	3	10.1	7.5–14.6	1.62
	Downstream	3	12.7	11.0–18.6	1.84

* No samples taken during May.
NS, no sample, creek bottom frozen.

General conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory, it is concluded that the operation of the Knolls and Kesselring installations did not adversely affect the radioactivity levels of the local environment. The results of the environmental surveys indicate that the levels of radioactivity detected at all times were within the standards established by the U.S. Atomic Energy Commission in the AEC Manual Chapter 0524, Radiation Protections Standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1968	October 1970

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2. Rocky Flats Plant[3]
January–December 1969

Dow Chemical Company
Golden, Colo.

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location, relative to population centers, is shown in figure 2. The basic goal guiding these operations is total containment of radioactive materials. The environmental survey program is designed to assure that radioactive materials released are below the AEC standards. Following a fire in a plutonium production building on May 11, 1969, environmental monitoring was intensified and expanded to include specific plutonium analyses of air, water, vegetation, and soil samples as well as gross alpha analyses (uranium plus plutonium) as previously performed.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Air samples from samplers programmed to operate 5 minutes of each hour were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner Station, Golden, Denver, and Westminster. The monthly average gross alpha radioactivity is shown in table 5. Fallout trays are mounted at the sampling stations as well as several other standby stations. Plutonium radioactivity in fallout is sum-

Table 5. Gross long-lived alpha radioactivity in offsite air samples, RFP environs July–December 1969

Location	Average concentration (fCi/m^3)					
	July	August	September	October	November	December
Boulder	12	10	8	8	8	8
Broomfield	10	24	8	10	8	10
Coal Creek	10	8	10	8	10	6
Denver	8	18	8	8	12	6
Golden	12	12	10	10	10	6
Lafayette	8	8	12	10	10	6
Marshall	20	42	18	18	16	10
Wagner Station	12	8	10	8	10	2
Westminster	16	10	10	14	12	10

---

[3] Summarized from "Environmental Survey, July–December 1969," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

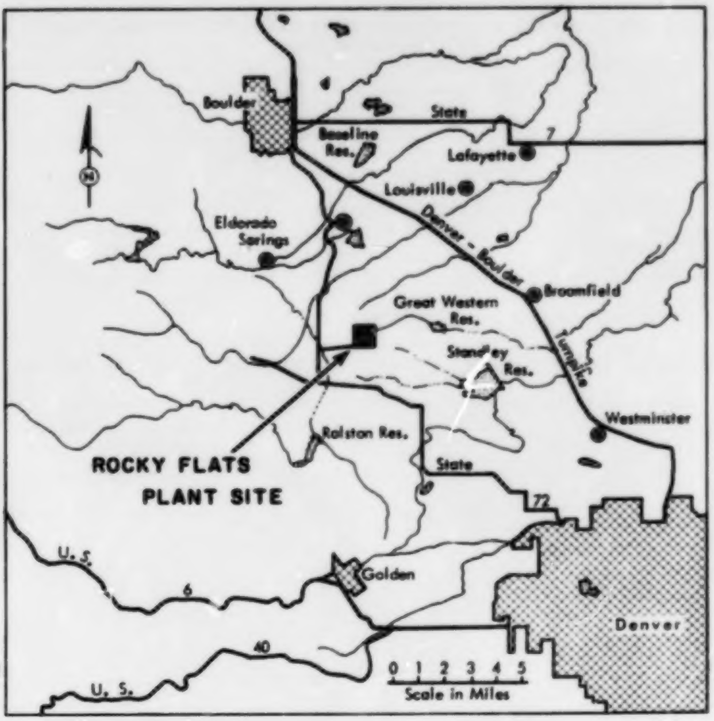
N
Boulder
State
7
Baseline Res.
Lafayette
Louisville
Eldorado Springs
Denver - Boulder Turnpike
Broomfield
Great Western Res.
Standley Res.
Westminster
Ralston Res.
ROCKY FLATS PLANT SITE
State
72
U.S.
6
Golden
Denver
40
U.S.
0 1 2 3 4 5
Scale in Miles

Figure 2. Location of Rocky Flats Plant

marized in table 6. In addition to the air sampling program, 8-hour high-volume air samples are collected periodically at one of the sampling stations. These samples are analyzed specifically for plutonium.

Table 6. Plutonium radioactivity in fallout, RFP environs, July–December 1969

Location	Number of days measured	Average plutonium radioactivity (pCi/m²-month)[a]
Arvada	133	1.73
Boulder	135	9.61
Broomfield	137	2.05
Coal Creek	125	5.72
Denver	151	1.84
Eastlake	140	13.3
Golden	125	3.24
Lafayette	151	2.38
Marshall	151	3.89
Superior	151	3.46
Wagner Station	151	20.0
Westminster	151	1.51

[a] This includes worldwide fallout.

Water

Four reservoirs in the area are sampled biweekly. Local community tap water samples are collected monthly. Other streams and lakes in the area are sampled twice a year. These samples are analyzed for gross alpha radioactivity content (uranium plus plutonium). Selected samples are analyzed for plutonium by alpha spectrometry. Tables 7 through 9 summarize the results of the water sampling program. The concentration guide for radioactivity above natural background for water (applicable to the averaged annual levels) is 10 pCi/liter where the concentration of individual radionuclides is not known and 1,600 pCi/liter for plutonium-239. These guides apply to the general population.

Table 7. Radioactivity in reservoir samples, RFP environs, July–December 1969

Reservoir	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)			Plutonium radioactivity (pCi/liter)		
	Number of samples	Range	Average	Number of samples	Range	Average
Baseline	9	0.1– 3.3	1.0	4	<0.01–0.005	0.02
Great Western	[a] 24	.4– 5.0	2.1	4	.07– .25	.12
Ralston	10	1.1–13.2	5.7	6	< .01– .20	.06
Standley	[a] 24	.2– 4.4	1.6	3	< .01– .05	.02

[a] Additional samples were collected following the May fire.

Table 8. Radioactivity in community tap water, RFP environs, January–December 1969

Station	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)			Plutonium radioactivity (pCi/liter)		
	Number of samples	Range	Average	Number of samples	Range	Average
Arvada	8	0.2–11.4	2.6	4	<0.01–0.07	0.04
Boulder	8	.1– .8	.4	3	< .01– .08	.03
Broomfield	8	.1– .9	.5	3	< .01– .06	.02
Denver	9	.2–10.	2.2	3	< .01– .11	.04
Golden	8	.1– 2.5	.8	3	< .01– .10	.05
Lafayette	9	.1– 1.7	.7	3	< .01– .02	.01
Louisville	9	.1– 1.9	.7	3	< .01– .01	<.01
Thornton	8	.2– 7.7	1.6	3	.05– .10	.08
Westminster	10	.8– 2.6	2.6	4	< .01– .40	.13

Table 9. Radioactivity in surface water, RFP environs, 1969 [a]

Sampling Date (1969)	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)			Plutonium radioactivity (pCi/liter)		
	Number of samples	Range	Average	Number of samples	Range	Average
May–June	53	0.1–[b]16	1.8	5	<0.01–[d]1.24	0.13
August	24	< .1–[c]27	3.1			
Total	77	<0.1–27	2.2			

[a] Other than those presented in tables 7 and 8.
[b] Walnut Creek at Indiana Avenue.
[c] Long Lake.
[d] Plant effluent course at east cattle fence.

Vegetation

Vegetation samples have been collected semiannually. These samples are radiochemically analyzed for uranium and plutonium. Results are summarized in table 10. With the implementation of extensive fallout and soil sampling programs, vegetation sampling will be cut back in future years.

Table 10. Gross alpha radioactivity in vegetation samples, RFP environs, 1969

Sampling date (1969)	Distance from plant (miles)	Number of samples	Gross alpha radioactivity (uranium + plutonium) (pCi/kg dry weight)	
			Range	Average
May–June	<4	72	<10–290	78
	4–18	43	<10–330	78
August–September	<4	54	<10–260	58
	4–18	44	<10–390	64

Soil

Soil samples are taken from the surrounding area, at remote locations, and from lake sediments. These are analyzed for plutonium and strontium-90. The plutonium-239-strontium-90 ratio is calculated as a basis of comparison with ratios established in worldwide fallout of bomb debris. Plutonium results are summarized in table 11 through 13. Strontium-90 results will be reported in subsequent reports.

Table 11. Plutonium radioactivity in vegetation samples, RFP environs, 1969

Sampling date (1969)	Distance from plant (miles)	Number of samples	Plutonium radioactivity (pCi/kg dry weight)	
			Range	Average
May-June	<4	72	<5–160	20
	4–18	43	<5–225	14
August-September	<4	54	<5–130	16
	4–18	44	<5–350	24

Table 12. Plutonium in surface soil samples, RFP environs, January–December 1969

Distance from plant (miles)	Number of samples	Plutonium content (dpm/g)	
		Range	Average
1	11	1.2–3.9	1.9
2	21	.4–6.7	1.4
5	16	.5–3.3	1.0
>5	14	.1– .6	.2

Table 13. Plutonium in reservoir sediments, RFP environs, January–December 1969

Reservoir	Number of samples	Plutonium content (dpm/g)	
		Range	Average
Great Western	9	0.3–2.4	1.0
Baseline	4	.1–1.3	.6
Ralston	4	.5– .9	.7
Standley	4	.5–1.0	.7

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	February 1970

Reported Nuclear Detonations, September 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that it had conducted two nuclear tests during September 1972.

On September 21, 1972, one nuclear test in the low-intermediate yield (20-200 kilotons TNT equivalent) was conducted underground at the Nevada Test Site by the Atomic Energy Commission.

The other test was of low yield (less than 20 kilotons TNT equivalent) and was conducted underground on September 26, 1972 at the Atomic Energy Commission's Nevada Test Site.

Seismic signals, presumably from a Soviet underground nuclear explosion were recorded by the United States. The signals originated at approximately 5:00 a.m., EDT, September 21, 1972, in the southern Ural area of the USSR, and were equivalent to those of an underground nuclear explosion of the yield range of 20-200 kilotons.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A COMPARISON OF FILM BADGES AND THERMOLUMINESCENT DOSIMETERS USED FOR ENVIRONMENTAL MONITORING. *Charles K. Fitzsimmons, William Horn,* and *William L. Klein. Radiation Data and Reports, Vol. 13, October 1972,* pp. 537-546.

Data obtained from two concurrent dosimetry networks operated by the National Environmental Research Center, Las Vegas, Nev., are compared. One network utilizes the film badges and the other, thermoluminescent dosimeters (TLD). Gamma exposures from a few mR to approximately 1 R due to both natural background and fission products in the environment are more easily and accurately measured by the TLD system. Where the minimum detectable exposure for film is about 45 mR, the TLD sensitivity is on the order of 1 mR (which allows measurement of monthly background exposures). The insensitivity of TLD's to environmental heating, humidity, light damage, and pressure makes them ideal for use in the extreme conditions encountered in the desert. Heat damage to the film was seasonal with the greatest losses occurring in the summer. During July 1967, 71 percent of the film badges issued were heat or light damaged, while no loss of TLD data occurred. No background information was obtained from film data during 1967, but the geographical variations in background exposure rates were clearly disclosed by the TLD's.

KEYWORDS: background exposure, environment, film badges, gamma radiation, Nevada Test Site, thermoluminescent dosimeters.

RADIATION DATA AND REPORTS

Volume 13, Number 11, November 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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- Department of Agriculture
- Department of Commerce
- Department of Health, Education, and Welfare
- Environmental Protection Agency
- Atomic Energy Commission

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DATA AND REPORTS

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

Environmental Radioactivity in Illinois, 1970

Moshe J. Shmuklarsky[1]

The contribution of radioactivity to the Illinois environment during 1970 resulting from the operation of nuclear power plants and from other major natural and manmade sources is presented. The environmental surveillance programs of the Dresden, Quad-Cities and Zion nuclear power stations are described. Dresden Unit 1 radioactive gaseous and liquid releases for the past 11 years, and Dresden Unit 2 discharges for 1970 are summarized. On the basis of data gathered during 1970, it is concluded that the effect of nuclear power plant operations on the radioactivity level of most environmental media was hardly distinguishable from the natural and fallout radioactivity. The only measured environmental radiation effect of nuclear power generation within the State was an apparent increase of a few millirem per year in the external background exposure in the vicinity of Dresden-1.

The many sources of radioactivity in the environment may lead to population exposure through a variety of direct and indirect pathways. In order to estimate population dose from environmental radiation, it is necessary to identify and quantify the concentration of radionuclides in each exposure pathway. Knowledge of the sources and pathways of environmental radiation is the first step in the control, reduction and possible prevention of unnecessary population exposure.

By far the greatest source of radiation exposure to the population is natural background radiation from cosmic rays and from terrestrial, gamma-emitting, naturally-occurring radionuclides. These sources do not lend themselves to control, but because of their variability with time and place, it is essential to monitor them in order to detect any contribution that may arise from manmade, controllable, sources of environmental radiation.

Medical x rays are the greatest controllable source of population exposure. However, the benefit to the patient from the diagnostic procedure usually outweighs the risk from exposure to radiation. Generally, the use of radiation in the healing arts is not classified under environmental radiation per se.

Nuclear facilities represent one source of environmental radiation which is amenable to controls; hence, it is appropriate to assess the contribution of this source to population dose. Releases of radioactivity from nuclear power operation contribute a small part of the total population exposure to ionizing radiation at present. Such releases, however, increasingly engage the concern of the environmentalists, the public health authorities, and the general public, particularly in light of the steady increase in number and output of nuclear power plants and ancillary facilities. A measure of the projected increase in nuclear power plants in the United States may be obtained from the following tabulation:[2]

---

[1] Mr. Shmuklarsky is with the Field Operations Division, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460.

[2] AEC News Release, March 31, 1972

	Number	*Capacity (MW(e))*
Plants operable	23	10,007
Plants being built	54	45,794
Planned (reactors ordered	57	56,702
Total	134	112,503

For the purpose of gaining perspective with respect to population exposure, it is important to document such factors as: normal background radiation, radioactive releases to the environment, population distribution around reactor sites and vectors that bear upon radiation exposure to the population in the vicinity of nuclear power plants.

The State of Illinois had two nuclear power plants in operation during 1970; these were Dresden Nuclear Power Station, Units 1 and 2. Five other nuclear power plants were in various stages of construction: Dresden Station Unit 3, Quad-Cities Station Units 1 and 2 and Zion Station Units 1 and 2. By 1973, seven nuclear power plants are scheduled to operate commercially in Illinois with a total annual generating capacity of 5,646 net megawatts electric. Table 1 summarizes the rated power output, ownership (*1*), and pertinent population data for these reactors and those in the planning stages. The locations of the reactor facilities are shown in figure 1.

During 1970, preoperational environmental monitoring programs were conducted around the Quad-Cities and the Zion sites. Data gathered in these programs will provide a base-line for measuring future changes in the environmental radiation around these facilities. In addition, the preoperational data also provide a basis for comparison with data obtained in the environmental monitoring program of the Dresden Station.

Table 1. Major nuclear power facilities in Illinois, 1970[a]

Name of facility	Operator	Reactor type[b]	Rated power		Year of startup	Location	Population[c]		
			Net MW(e)	MW(t)			5 miles	10 miles	50 miles
Operating:									
Dresden 1	Commonwealth Edison Co.	BWR	210	700	1959	Morris	5,090	32,288	6,137,524
Dresden 2	Commonwealth Edison Co.	BWR	809	2,527	1970	Morris	5,090	32,288	6,137,524
Under construction:									
Dresden 3	Commonwealth Edison Co.	BWR	809	2,527	1971	Morris	5,090	32,288	6,137,524
Quad-Cities 1	Commonwealth Edison Co. & Iowa-Illinois Gas & Electric Co.	BWR	809	2,511	1971	Cordova	5,845	26,619	600,113
Quad-Cities 2	Commonwealth Edison Co. & Iowa-Illinois Gas & Electric Co.	BWR	809	2,511	1972	Cordova	5,845	26,619	600,113
Zion 1	Commonwealth Edison Co.	PWR	1,100	3,391	[d]1973	Zion	46,196	190,314	7,150,792
Zion 2	Commonwealth Edison Co.	PWR	1,100	3,391	[d]1973	Zion	46,196	190,314	7,150,792
Planned:									
Lasalle 1	Commonwealth Edison Co.-Iowa	BWR	1,078	3,293	[d]1977	Seneca	720	8,901	943,027
Lasalle 2	Commonwealth Edison Co.-Iowa	BWR	1,078	3,293	[d]1978	Seneca	720	8,901	943,027
Commonwealth Edison 1 (Comed west 1)	Commonwealth Edison Co.	PWR	1,100	3,425	[d]1978	Not announced	Not available	22,595	975,832
Commonwealth Edison 2 (Comed west 2)	Commonwealth Edison Co.	PWR	1,100	3,425	[d]1979	Not announced	Not available	22,595	975,832
Illinois Power Company 1	Commonwealth Edison Co.	PWR	800	Not available	Not available	Clinton	Not available	Not available	Not available
Summary			10,802	30,994			57,851	280,717	15,807,288

[a] Based on reference (*1*) and personal communication from Dr. John C. Golden, staff radioecologist, Commonwealth Edison Co.
[b] BWR, Boiling Water Reator; PWR, Pressurized Water Reactor.
[c] Based on 1970 census.
[d] Estimated.

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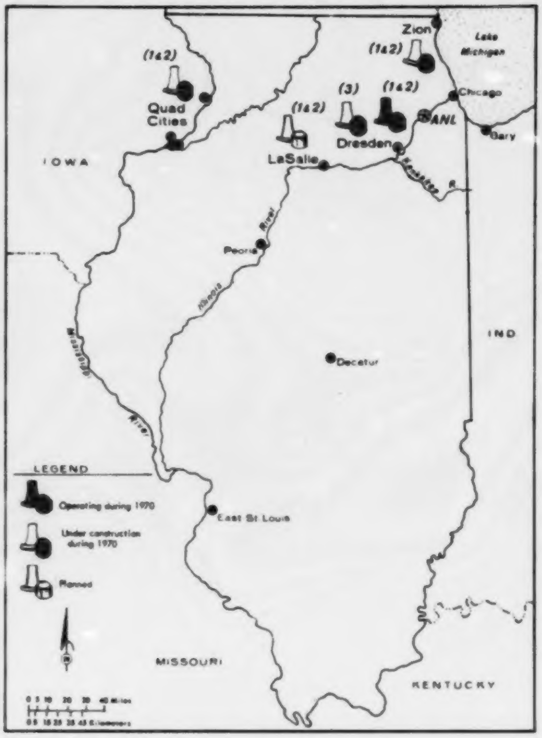

Figure 1. Location of reactor facilities

A variety of other environmental monitoring programs was in effect in the State. Routine statewide surveillance activities were conducted by the Illinois Department of Public Health, the Argonne National Laboratory (ANL) and the United States Environmental Protection Agency. The findings of these programs are published periodically in *Radiation Data and Reports* (*2,3*), ANL semiannual reports (*4*), and the Illinois Department of Public Health annual reports (*5*). In addition, a comprehensive survey of Lake Michigan, the source of condenser cooling water for the Zion Station as well as other nuclear power plants, was performed by the University of Michigan during 1969-1970 (*6*).

Dresden Nuclear Power Station

Environmental surveillance around nuclear power reactors

The Dresden Nuclear Power Station is located in Grundy County, Ill., where the Kankakee and Des Plaines Rivers merge to form the Illinois River. The site is 8 miles east of Morris, Ill. (1970 population total, 8,194) and approximately 50 miles southwest of Chicago. There are three boiling water reactors at the Dresden site. Unit 1 with a net electrical capacity of 210 megawatts has been in commercial service since August 1960. Unit 2, with a net electrical capacity of 809 megawatts, achieved criticality in January 1970 and was under a power test program for the remainder of the year. Unit 3, which is identical to Unit 2, was in the final stages of construction. Adjacent to and south of the Dresden Station is the Midwest Fuel Recovery Plant which also was in its final stages of construction during this period. The location of the Dresden Station in relation to the fuel recovery plant and the nearby communities and the environmental sampling locations are shown in figures 2 and 3.

Gaseous waste system

Dresden Unit 1 has a 300 foot stack through which the radioactive gaseous effluents are released into the atmosphere. Noncondensable radioactive isotopes of the noble gases, krypton and xenon, are removed from the primary coolant by an air ejector and exhausted into shielded piping which provides a holdup of 20 minutes for the decay of the short-lived isotopes of the noble gases. Before entering the stack, the gaseous effluents are filtered to remove the radioactive particulates resulting from neutron activation and decay of the noble gases. The relatively small quantity of radioactive gases from the turbine gland seal off-gas system is delayed for 2 minutes prior to discharge via the stack to provide sufficient decay time for the activation gases, nitrogen-16 (half-life, 7.4 seconds) and oxygen-19 (half-life, 29 seconds). Ventilation air from the reactor containment structure and the turbine building provides initial dilution in the stack before release of the effluents to the atmosphere.

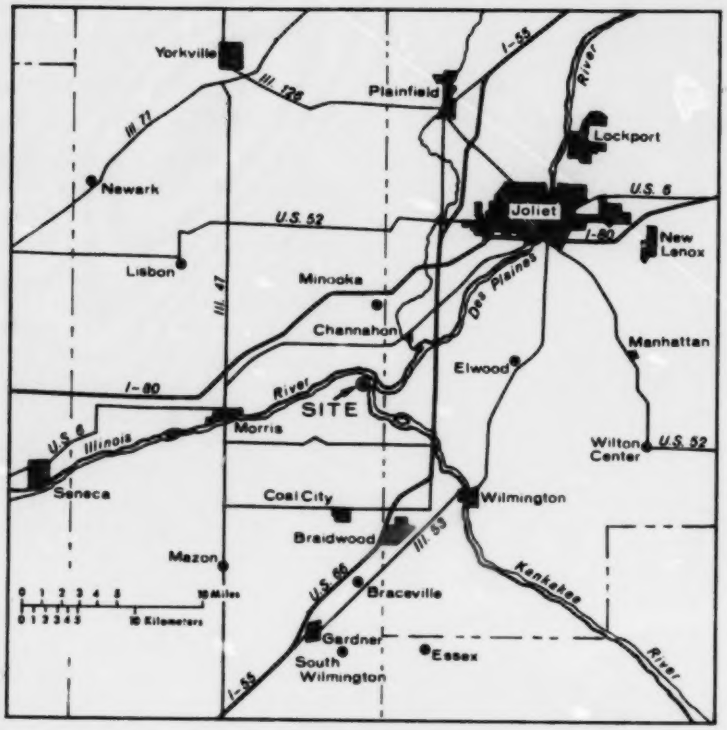
Yorkville
Ill 126
Plainfield
I-55
River
Lockport
Ill 71
Newark
U.S. 6
Joliet
U.S. 52
I-80
New Lenox
Lisbon
Ill 47
Minooka
Channahon
Des Plaines
Manhattan
Elwood
I-80
River
SITE
U.S. 6
Illinois
Morris
Wilton Center
U.S. 52
Seneca
Coal City
Wilmington
Braidwood
Ill 53
Mazon
Kankakee
U.S. 66
Braceville
0 1 2 3 4 5 10 Miles
0 1 2 3 4 5 10 Kilometers
Gardner
South Wilmington
Essex
River
I-55

Figure 2. General location of the Dresden Nuclear Power Station and nearby communities

Dresden Units 2 and 3 have identical gaseous waste systems with a 310 foot exhaust stack common to both units. Noncondensable radioactive gases from the primary coolant are delayed for 30 minutes and filtered by either of two parallel sets of particulate filters before being discharged via the stack. Radioactive gases from the turbine gland seal are held up for about 1.75 minutes before release. In addition, Units 2 and 3 have a vent stack for discharge of effluents originating in the reactor building. A more detailed description of the gaseous waste system in boiling water reactors in general, and the Dresden Units 1, 2, and 3 in particular, is given in references *7-10*.

Prior to the operation of Dresden Units 2 and 3, the discharge limit for Unit 1 noble gas release rate was 0.7 curies per second. During 1970, with the anticipated power operations of Units 2 and 3, new limits were set by the Atomic Energy Commission (AEC). These limits account for the additive effect of simultaneous emissions of noble gases from the three discharge outlets at the Dresden Station. The release rates for the noble gases from all three sources onsite are guided by the formula:

$$\left[\frac{Q_1}{0.56} + \left(\frac{Q_{(2\text{ or }3)}}{0.7} \text{ or } \frac{Q_{(2\text{ and }3)}}{0.9}\right) + \frac{Q_{RS}}{0.09}\right] \leq 1 \ldots (1)$$

Where:

Q_1 = release rate from the stack of Unit 1 (Ci/s),

$Q_{(2\text{ or }3)}$ = release rate from Units 2 and 3 stack (Ci/s) with only Unit 2 or 3 operating, but not both,

$Q_{(2\text{ and }3)}$ = release rate from Units 2 and 3 stack (Ci/s) with both Units 2 and 3 operating, and

Q_{RS} = release rate from Units 2 and 3 reactor building ventilation stack (Ci/s).

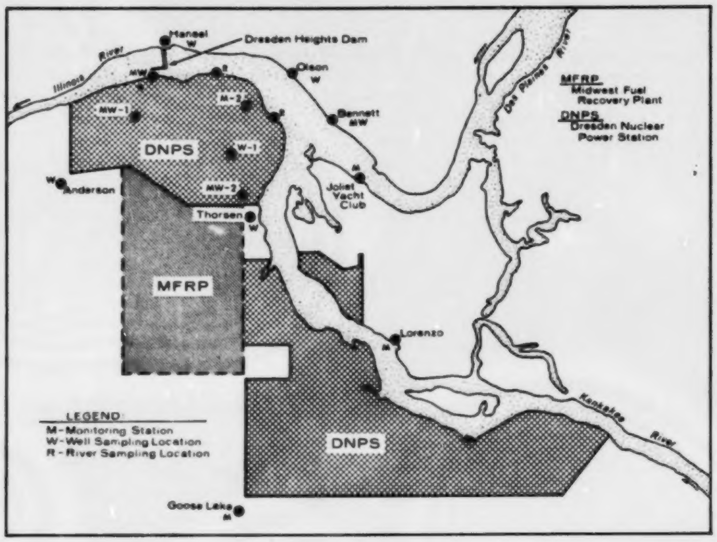
Hansel
W
Dresden Heights Dam
Illinois River
MW
R
Olson
W
MW-1
M-2
R
Bennett
MW
DNPS
W-1
W Anderson
MW-2
Thorsen
W
M
Joliet
Yacht
Club
Des Plaines River
MFRP
Midwest Fuel
Recovery Plant
DNPS
Dresden Nuclear
Power Station
MFRP
Lorenzo
M
Kankakee River
DNPS
LEGEND:
M-Monitoring Station
W-Well Sampling Location
R-River Sampling Location
Goose Lake
M

Figure 3. Monitoring and sampling locations

Similarly, the release limits for halogens and particulates were also adjusted in order to maintain concentration at the site perimeter within the original limits applied to the Dresden Unit 1. A formula similar to equation (1) is used to account for the additive effect of the discharges from the various outlets onsite.

Radioactive gaseous effluents

Radioactive gaseous effluents are generally classified as either noble and activation gases, which originate in the reactor core from fission and neutron activation, or halogens and particulates, which are mostly decay products of the short-lived isotopes of the noble gases with some being activation products. The rate of production of the radiogases is proportional to the plant's thermal output. Their release rate, however, is a function of factors such as fuel cladding, integrity, waste treatment system, waste management practices, etc. (*11,12*).

In a special study of the Dresden Unit 1 effluents by the Public Health Service (PHS) (*9*), the gaseous effluents were determined to be mostly short-lived noble gases. Since these noble gases are generally higher-energy gamma emitters, they are the major contributors to the whole body genetically significant dose in the vicinity of an operating boiling water reactor. However, in less than 2 days decay time after release, the dose from these radiogases decreases by at least two orders of magnitude (*13*). The longer-lived noble and activation gases detected during the special study were xenon-133 (9,000 Ci/a), krypton-85 (3 Ci/a), and tritium (0.2 Ci/a) in the total annual discharge of 240,000 curies. Within less than 2 months decay time, the dose from xenon-133 (half-life, 5.27 days) decreases by more than three orders of magnitude. Krypton-85 and tritium do not contribute significantly to the population dose in the vicinity of the plant because of their relatively low discharge quantity and weak beta radiation. The major concern regarding these two nuclides, having half-lives of 10.7 and 12.3 years, respectively, is the prospect for their long-term, worldwide environmental buildup. Detailed discussions regarding krypton-85 and tritium sources, their present worldwide inventory, future estimated accumulation and their interactions with biological systems can be found in references *14-20*.

The halogens and particulates formed before and during the delay time in the gaseous waste system are removed by particulate and charcoal filters. Their total activity released into the atmosphere is generally a small fraction of the noble gas activity. However, they are mostly long-lived radionuclides which may be

Table 2. Isotopic composition of the noble gas discharges, Dresden Nuclear Power Station, 1970[a]

Radionuclide	Half-life	Unit 1				Unit 2				Total site	
		Percent of total release			Annual release[c] (Ci)	Percent of total release			Annual release[c] (Ci)	Total release (Ci)	Percent total
		Maximum	Minimum	Mean[b]		Maximum	Minimum	Mean[b]			
Xenon-135	9.2 hours	15.5	14.1	15	136,000	29.6	23.4	27	67,000	203,000	17.5
Krypton-87	1.3 hours	13.2	12.2	13	118,000	21	14.7	18	45,000	163,000	14.0
Xenon-133	5.3 days	8.5	6.8	7.4	67,000	22	14.5	18	45,000	112,000	9.8
Krypton-88	2.8 hours	20.3	9.3	15	136,000	19.1	13.3	17	42,500	178,000	15.5
Krypton-85m	4.4 hours	4.5	3.9	4.1	37,000	10.3	7.9	9	22,500	59,500	5.2
Xenon-138	17 minutes	32.8	26.4	30	270,000	11.2	2.6	5.7	14,500	284,500	24.5
Xenon-135m	15 minutes	18.7	13.3	16	145,000	11.3	1.1	5.3	12,500	157,500	13.5

[a] Data taken from reference *22*.
[b] Mean value based on three analyses performed during August, November, and December 1970, on gaseous samples taken at the steam jet air ejector.
[c] Annual release values based on total annual release and mean percent of total release.
[d] Mean value for Unit 2 based on five analyses performed during August—December 1970 on gaseous samples taken at the steam jet air ejector.

deposited on and assimilated into vegetation or accumulated in drinking water sources. Thus, through a variety of pathways they may contribute to the radiation exposure of the population at large. In the PHS special study (*9*), iodine-131 was found to be the critical radionuclide in the halogen and particulate stack discharges. The maximum potential exposure from iodine-131, via the pasture-cow-milk pathway, was estimated to be 0.28 millirem per year (*21*).

Table 2 provides a summary of the isotopic composition of the radioactive noble gases released from the Dresden Station and the contribution of each of the Dresden units to the total site releases during 1970. The Dresden Unit 1 isotopic composition values are based on three samples taken from the steam jet air ejector before discharge via the stack. The mean percentage composition of the various radiogases could be considered to be representative of the noble gas releases from Unit 1 during normal power operation.

The noble gases from Unit 2 were sampled and analyzed on seven occasions. However, the percent isotopic composition for Unit 2 includes the results of only five of the samples. The first two analyses were not included since they were taken early during the power test program when the predominating radionuclides in the core were short-lived. For these two samples, the short-lived radiogases, xenon-138 and krypton-87, constituted more than 50 percent of the noble gas activity. The percentage composition of these nuclides decreased as the power test program progressed. The five samples collected during the latter part of the program are considered more representative of the noble gas discharge composition for 1970. However, since the core inventory and discharges of radioactive materials are a function of factors such as thermal output, power history, fuel residence time, etc. (*23*), the percent composition for Unit 2 can be expected to change in time and is not considered to be typical for normal power operation.

Table 3. Estimated stack release rates of particulate radionuclides and gaseous iodine-131, Dresden Unit 1, 1970

Radionuclide	Half-life	Number of analyses	Release rate[a] (pCi/s)			Percent of release rate[b]	Annual releases[c] (Ci)
			Maximum	Minimum	Mean		
Cobalt-58	71.3 days	15	140	<8	26	1.1	0.036
Cobalt-60	5.26 years	16	95	2.5	25	1.0	.033
Strontium-89	52.7 days	15	2,300	220	970	40	1.3
Strontium-90	27.7 years	15	25	2	5	.2	.007
Cesium-137	30 years	16	55	13	35	1.4	.046
Barium-140	12.8 days	17	710	70	430	18	.6
Iodine-131	8.05 days	17	3,230	200	920	38	1.25

[a] Release rates are taken from reference 9.
[b] Percent of release rate is based on the total release rate for iodine and particulates and the mean release rate for each radionuclide (gaseous fission products are not included).
[c] Annual releases based on the percent release rate and halogen and particulates total release from Unit 1 of 3.3 curies during 1970.

Table 3 provides a summary of the stack release rates for particulate radionuclides and gaseous iodine from Dresden Unit 1. The large variation in discharge rates for the various nuclides indicates that the release rates of the individual radionuclides and their amount relative to the total releases vary appreciably among samples. Nevertheless, the mean discharge rates provide a good indication of the relative contribution by each of the nuclides to the total activity of the halogen and particulate discharges. The 1970 estimated annual release of each of the nuclides is given in the last column. These releases are based on the percentage contribution of each nuclide to the total activity and on Unit 1 halogen and particulate annual discharges of 3.3 curies.

Table 4 summarizes Dresden Unit 1 annual noble and activation gas release rates for the past 11 years (*12*). Generally, the radioactive discharges increased with power history. A reduction in the total discharges during 1967 and 1968 was probably due to the removal and replacement of stainless-steel-clad fuel elements—a number of which were leaking—with new elements of Zircaloy cladding. During 1969 and 1970, the total activity released resumed the upward trend. However, an examination of the average release of radioactivity per megawatt electrical output shows a decrease in 1970 to the 1964-66 levels. This suggests that Unit 1 noble and activation gas discharges leveled off during this period.

A summary of the 1970 annual releases of radioactive gaseous effluents from the Dresden Station and the percentages of these releases relative to the permissible limits for each of the units is provided in table 5 (*25*). The Dresden Units 1 and 2 percentages are based upon the technical specification limits of each unit as expressed in equation (1) and, as expressed in a similar formula, for the halogen and particulate effluents. The discharge of gaseous effluents as percentage of the site limit is the sum of the individual percentages for each of the units. The noble and activation gas releases during 1970 were 6.3 percent of the site limit.

For the noble and activation gas emissions, the site limit corresponds to an estimated maximum annual exposure of 500 millirems of external whole body dose at the site boundary or at a point of maximum potential ground level exposure offsite. Based on the 1970 noble and activation gaseous releases, the maximum potential whole body annual dose to an individual offsite was approximately 32 millirems.

Stack release limits for halogens and particulates include a reduction factor of 700 applied to the 10CFR20 (*26*) air concentration limits to allow for the potential environmental transfer and concentration of the radionuclides in milk. Thus the direct radiation from these nuclides and their contribution to the external whole body dose are negligible compared to the noble and activation gases.

Table 4. Annual noble and activation gas releases, Dresden Unit 1, 1960–1970

Year	Annual release[a] (Ci)	Average release rate		Gross generation (MW(e)h)[c]	Average release (Ci/MW(e)h)
		Annual (Ci/s)	Percent of limit[b]		
1960	[d]3,200	0.0001	0.02	275,610	0.012
1961	[d]6,400	.0002	.04	555,141	.012
1962	[d]64,000	.0002	.36	1,249,602	.051
1963	72,000	.0023	.41	989,721	.074
1964	520,000	.017	3.0	1,037,511	.52
1965	610,000	.029	3.5	1,018,344	.61
1966	740,000	.024	4.3	1,474,832	.50
1967	260,000	.0083	1.5	853,567	.31
1968	240,000	.0076	1.4	966,792	.25
1969	860,000	.028	4.8	873,285	.98
1970	910,000	.029	5.2	1,428,826	.64
Average	390,000	0.013	2.2	974,840	0.36

[a] Taken from reference *12* except as noted.

[b] Percent of limit based on the release limit of 0.56 (Ci/s) applicable for Unit 1.

[c] Data taken from reference *24*.

[d] Based on annual release rates taken from exhibit 2 of testimony by Robert Pavlick of the Commonwealth Edison Company, submitted at the Illinois Pollution Control Board hearings, December 8, 1970.

Table 5. Annual releases of radioactivity in the gaseous effluents, Dresden Nuclear Power Station, 1970

Type of release by unit	Annual release[a] (Ci)	Release rate (Ci/s)	Annual limit[a] (Ci)	Release rate limit (Ci/s)	Percent of limit[a]
Noble and activation gases:					
Unit 1	9.1×10^5	0.03	1.8×10^7	0.56	5.2
Unit 2	2.5×10^5	.008	2.2×10^7	.7	1.1
Total	1.16×10^6				6.3
Halogen and particulates:					
Unit 1	3.3	1.06×10^{-7}	75	2.4×10^{-6}	4.3
Unit 2	1.6	$.51 \times 10^{-7}$	110	3.5×10^{-6}	1.4
Total	4.9				5.7

[a] Values taken from reference *25*.

Radioactive liquid waste system

The Dresden Unit 1 liquid waste system and discharge canal are independent of the waste system and discharge canal shared by Units 2 and 3. The condenser coolant water used by the Dresden plants for dissipating excess heat and for initial dilution of radioactive waste is drawn from the Kankakee and Des Plaines Rivers and discharged into the Illinois River. In order to preclude any detrimental thermal effect in the portion of the Illinois River receiving the outflow of Units 2 and 3 coolant water, a cooling lake was constructed southeast of the Dresden site, below the Midwest Fuel Recovery Plant.[3] Units 2 and 3 condenser coolant water will be diverted into the lake in order to dissipate excess heat by evaporation prior to discharge into the Illinois River.

The radioactive liquid waste systems of the Dresden plants include capabilities for holdup, filtration, evaporation, and demineralization. Liquid wastes are handled on a batch basis and treated according to their conductivity and radioactivity levels. Low level radioactive waste is usually filtered, while intermediate and high-level waste undergoes additional treatment by evaporation or demineralization. Processed liquid waste is either reused by the plant or discharged into the condenser coolant water. The rate of discharge into the coolant water canal is based on the radioactive concentration of the batch sample and on the water dilution flow rate at the discharge canal. When only gross beta analysis is performed, the technical specification requires that the gross beta activity in the discharge canal above background shall not exceed the average annual concentration of 1×10^{-7} μCi/ml (100 pCi/liter). For an unidentified mixture of liquid waste, all activity present is assumed to be due to the most restrictive isotope potentially present in the waste. The unidentified mixture limit is generally at least two orders of magnitude more restrictive than the limit otherwise applicable in the case of known isotopic composition.

The annual average condenser coolant water flow rate of Unit 1 is approximately 160,000 gallons per minute and the corresponding flow rate of Units 2 and 3 coolant water is approximately 940,000 gallons per minute. This water provides the initial dilution needed to maintain the radioactivity concentration in the discharge canal within the technical specification limits. A more detailed discussion of the sources of radioactive liquid wastes in nuclear power plants, the liquid waste systems, and treatment practices for the various categories of wastes can be found in references *7,8*, and *27*.

Radioactive liquid waste

The radioactive liquid waste effluents generally contain many of the same radionuclides found in the particulates and halogens of the gaseous effluents. These nuclides, as mentioned earlier, are neutron activation products and decay products of the short-lived radioactive noble gases. As a result of storage and proc-

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[3] Operation of the cooling lake began in the fall of 1971.

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Table 6. Estimated radionuclide concentrations in undiluted liquid waste (soluble portion only) exclusive of tritium, Dresden Unit 1, 1970

Radionuclides	Half-life	Radionuclide concentration[a] (pCi/ml)			Percent of total mean concentration	Annual discharges[b] (Ci)	Percent of concentration limits[c]
		Maximum	Minimum	Mean			
Iodine-131	8.05 days	46	6	22	3.1	0.25	73
Strontium-90	27.7 years	30	8	15	2.1	.17	50
Strontium-89	52.7 days	220	24	117	16.7	1.35	39
Cesium-137	30 years	150	35	106	15.1	1.25	5.3
Cesium-134	2.05 years	80	7	40	5.7	.47	4.5
Cobalt-60	5.26 years	500	1	129	18.3	1.50	2.6
Cobalt-58	71.3 days	880	3	226	32.3	2.64	2.3
Barium-140	12.8 days	65	22	40	5.7	.48	1.3
Cerium-144	284 days	—	—	[d]8	1.1	.09	.8

[a] Data taken from reference 9, based on five samples collected over a 10-month period during 1967–1968.
[b] Based on the percent of total mean concentrations for each radionuclide and total radioactive liquid waste discharge from Unit 1 of 8.2 curies for 1970.
[c] Based on the mean concentration and the concentration limit in water as specified in 10CFR20 (*26*).
[d] Result of only one measurement.

essing time, most of the short-lived nuclides in the liquid waste decay before release. Consequently, the radionuclides released are mostly those with long half-lives. The percentage contribution of individual radionuclides to the total activity of the liquid effluents is considerably different from the corresponding values in the gaseous effluents. The less volatile and more soluble nuclides contribute a greater percentage of the liquid-waste activity. The insoluble radionuclides tend to be deposited, absorbed and accumulated downstream from the plant along the river bottom. The soluble nuclides, however, are easily transported and incorporated into the metabolic processes of biological systems and, thus, are much more likely to lead to population exposure.

Table 6 lists the major radionuclides found in a typical batch of liquid waste discharges with the average and range of the soluble nuclide concentrations. As was the case with the gaseous effluents, the wide ranges of concentrations for the individual nuclides in the liquid effluents indicate that the release rates, as well as the activity of the individual nuclides relative to the total releases, vary appreciably among samples. Thus, the mean discharge rate values and the estimated annual discharges for 1970 should be construed only as indicators of the order of magnitude and relative contribution of the individual radionuclides to the total liquid waste activity.

The relative importance of each of the nuclides from the standpoint of population exposure, based on the mean concentration as a percentage of the concentration limit (CL) (*26*) is given in the last column of table 6. The critical radionuclide in the liquid waste is found to be iodine-131.

The average tritum concentration for the

Table 7. Annual releases of radioactivity in liquid effluents, Dresden Unit 1, 1960–1970[a]

Year	Gross beta-gamma[b] (Ci)	Average release rate		Gross generation[e] (MW(e)h)	Average release rate (µCi/MW (e)h)
		Annual (µCi/ml)[c] (10^{-8})	Percent of limit[d]		
1960	0.77	0.23	2.3	275,610	2.7
1961	2.1	.63	6.3	555,141	3.8
1962	2.6	.79	7.9	1,249,602	2.1
1963	2.8	.84	8.4	989,721	2.8
1964	3.8	1.2	12	1,037,511	3.7
1965	8.7	2.6	26	1,018,344	8.5
1966	11.5	3.5	35	1,474,832	7.8
1967	4.3	1.3	13	853,567	5.1
1968	6.1	1.9	19	966,792	6.3
1969	9.5	2.9	29	873,285	11
1970	8.2	2.5	25	1,428,826	5.7
Average	5.5	1.7	17	974,840	5.4

[a] Exclusive of tritium.
[b] Data taken from reference *12*.
[c] Annual average release rate calculation based on the total annual discharge and on the average condenser water dilution flow rate of 160,000 gallons per minute.
[d] Percent of limit based on the limit of 1×10^{-7} µCi/ml for unidentified radionuclides in liquid wastes.
[e] Data taken from reference *24*.

liquid samples mentioned above was approximately 850 pCi/ml, which is more than the total activity of all the halogen and particulate nuclides combined. However, when this value is considered relative to the CL of tritium, it is found to be less than 1 percent of the limit.

Table 7 summarizes the annual releases of radioactivity (excluding tritium) from the liquid effluents of Dresden Unit 1 for the past 11 years. Like the trend of the gaseous discharges, the activity of the liquid discharges showed a tendency toward leveling off at the 1970 discharge level. This trend is clearly indicated by the average release rate per unit electrical energy (last column). The 1970 value of 5.7 μCi/MW(e)h is close to the average value of the previous years.

The average release rate of radioactivity from Unit 1, via the liquid waste, in the past 11 years was 16.7 percent of the unidentified mixture limit. As mentioned earlier, the percentage for a mixture of known isotopic composition is generally about two orders of magnitude less restrictive. Thus, the above percentage represents considerable overestimation.

Table 8 summarizes the 1970 discharges via the liquid effluents from Units 1 and 2 (*25*). The gross beta-gamma (exclusive of tritium) station discharge was 18 percent of the unidentified mixture limit. It is based on the total station discharge and total dilution water. The average annual tritium concentration at the coolant water discharge canals was a small percentage of the 3×10^{-3} μCi/ml concentration limit in water.

Dresden Nuclear Power Station environmental monitoring program

The Dresden environmental monitoring program has been in effect since 1958. With the anticipated power operation of the Dresden Units 2 and 3 and the Midwest Fuel Recovery Plant (MFRP), the scope of the surveillance program was subsequently broadened in a joint program by the General Electric Company, operator of the MFRP, and the Commonwealth Edison Company, operator of the Dresden Station. The expanded program was directed toward obtaining more extensive measurements of meteorological, radiological, and thermal parameters in order to minimize any future effects of the plants operation on the local environment. The findings of this program also increased the data base from which future evaluation of the station's impact on the local environment could be made with greater certainty. A summary of the program elements of the joint General Electric and Commonwealth Edison environmental monitoring program is provided in table 9 (*28*). The results of the monitoring program for 1970 are summarized and discussed below.

Radioactivity in air

Airborne radioactivity was monitored at 18 locations in and around the Dresden Station. Radioactive particulates were accumulated continuously on filter papers mounted on air samplers. The filters were collected weekly and analyzed for gross alpha and gross beta radio-

Table 8. Annual releases of radioactivity in the liquid effluents, Dresden Nuclear Power Station, 1970

Type of releases by unit	Total released (Ci)	Dilution water (ml)	Release rate (μCi/ml)	Release rate limit[a] (μCi/ml)	Percent of limit
Gross beta-gamma (exclusive of tritium):					
Unit 1	8.2	[b]3.3×10^{14}	2.5×10^{-8}	1×10^{-7}	25
Unit 2	12.8	[c]8.6×10^{14}	1.5×10^{-8}	1×10^{-7}	15
Summary	21.0	11.9×10^{14}	1.8×10^{-8}	1×10^{-7}	[d]18
Annual tritium discharges:					
Unit 1	5	3.3×10^{14}	1.5×10^{-8}	3×10^{-3}	0.0005
Unit 2	31	8.6×10^{14}	3.6×10^{-8}	3×10^{-3}	.0012
Summary	36	11.9×10^{14}	3.0×10^{-8}	3×10^{-3}	[d]0.001

[a] Based on concentration limit as specified in 10CFR20 (*26*).
[b] Based on an average water dilution flow rate in Unit 1 discharge canal of 160,000 gallons per minute.
[c] Based on an average water dilution flow rate in Units 2 & 3 discharge canal of 430,000 gallons per minute.
[d] Based on the total discharges from the station and on the sum of the dilution water of Unit 1 and Units 2 & 3 discharge canals.

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Table 9. Dresden Nuclear Power Station environmental monitoring program[a]

Sample type	Number of sites	Frequency of collection	Type of analysis	Minimum detectable levels (MDL) and units[b]
Airborne particulates	17	Monthly	Gross alpha	0.001 pCi/m^3
	17	Weekly	Gross beta	.001 pCi/m^3
Airborne iodine-131	17	Weekly	Iodine-131	.03 pCi/m^3
Ion-chambers	17	Weekly	Gross gamma	.6 mrem/week
TLD	17	Quarterly	Gross gamma[c]	.3 mrem/week
Well water	1	Monthly	Gross alpha	2 pCi/liter
	6		Gross beta	2 pCi/liter
	10	Quarterly	Gross alpha	2 pCi/liter
			Gross beta	2 pCi/liter
			Tritium	1,000 pCi/liter
Surface water	3	Weekly	Gross beta	2 pCi/liter
	1	Quarterly	Gross alpha	2 pCi/liter
			Gross beta	2 pCi liter
	5		Tritium	1,000 pCi/liter
	4	2 to 4 annually	Strontium-89	.5 pCi/liter
			Strontium-90	.5 pCi/liter
	1	Semimonthly	Gross beta	2 pCi/liter
	3	Semiannually	Gamma scan	(d)
			Gross beta	2 pCi/liter
Precipitation and deposition	2	Monthly	Gross alpha	20 pCi/m^2
	4		Gross beta	20 pCi/m^2
	4		Tritium	1,000 pCi/liter
Milk	2	Weekly (April-September)	Iodine-131	10 pCi/liter
	2	Monthly	Strontium-89	1 pCi/liter
			Strontium-90	1 pCi/liter
			Cesium-137	10 pCi/liter
			Barium-140	10 pCi/liter
			Iodine-131	10 pCi/liter
Fish	3	2 to 4 annually	Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
			Gamma scan	(d)
Foodstuff	3	Harvest time	Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
			Cesium-137	10 pCi/kg
Grass	2	Monthly (April-September)	Gross beta	20 pCi/kg
	2		Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
			Cesium-137	10 pCi/kg
			Iodine-131	10 pCi/kg
Vegetation	18	Annually[e]	Gross alpha	20 pCi/kg
			Gross beta	20 pCi/kg
	3		Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Cattle feed	2	October and January	Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
			Cesium-137	10 pCi/kg
Aquatic plants	2	Semiannually	Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
			Gamma scan	(d)
Slime	4	Semiannually	Gross beta	20 pCi/kg
			Gamma scan	(d)
Soil	2	Annually	Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
			Cesium-137	10 pCi/kg
			Gamma scan	(d)
	2	Quarterly	Gross alpha	20 pCi/kg
			Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Bottom sediment	4	Semiannually	Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
	3		Gamma scan	(d)

[a] Taken from reference *28*.

[b] MDL, minimum detectable level. Since the MDL depends on factors such as analytical procedures, sample size, counting instrumentation, etc., the values given are not theoretical levels of detection but rather approximate values of sensitivity which indicate a practical minimum detection level.

[c] Beta radiation is not detected, because of the encapsulation of the TLD's.

[d] MDL is a function of the complexity of the spectrum, sample size, geometry used and instrumentation.

[e] At end of growing season.

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Table 10. Gross beta radioactivity in airborne particulates, Dresden Nuclear Power Station, 1970[a]

Sampling locations	Distance from station (miles)	Number of samples[b]	Radioactivity concentration (pCi/m³)		
			Maximum	Minimum	Mean
Onsite:					
#1	NW	52	[c]1.00	0.04	0.19
#2	NE	48	.57	.03	.18
#3	S	51	.53	.04	.16
Offsite:					
Bennet	1 NE	48	.47	.03	.15
Lorenzo	2.1 SSE	52	.47	.04	.14
Clay Product	2.5 S	52	.55	.03	.16
McCabe	2.9 WSW	49	.62	.08	.17
Channanon	4.2 NE	49	.50	.04	.16
Minooka	4.4 NNE	52	.47	.03	.16
Coal City	8.0 S	52	.49	.03	.15
Morris	8.0 SW	52	.51	.03	.16
Elwood	8.2 E	52	.48	.03	.16
Wilmington	8.6 SE	48	.47	.03	.14
Lisbon	12.2 NW	51	.57	.04	.16
Joliet	12.7 NE	52	.50	.03	.15
Plainfield	15.7 NNE	45	.54	.02	.16
Summary: Onsite		151	1.00	0.03	0.18
Offsite		654	0.62	0.02	0.16

[a] Data taken from reference 29.
[b] Sample collection frequency on weekly basis.
[c] Radiochemical analysis revealed 0.98 pCi/m³ of zirconium-95 and traces of radioiodine.

Table 11. Summary of the mean gross beta radioactivity in airborne particulates, 1970

Station	Number of samples	Radioactivity concentration (pCi/m³)				Annual summary
		Jan-Mar	Apr-June	July-Sept	Oct-Dec	
Dresden	805	0.09	0.28	0.20	0.06	0.16
Quad-Cities	154	.08	.24	.19	.05	.15
Zion	129	NA	NA	.18	.07	.13

NA, no analysis.

activity. None of them showed gross alpha radioactivity from long-lived nuclides above the minimum detectable level. A summary of the gross beta radioactivity is given in table 10.

Comparison between the mean gross beta radioactivity in airborne particulates around the Quad-Cities and the Zion Stations with that of the Dresden Station (table 11) indicates that the Dresden particulate discharges for 1970 were hardly detectable. The quarterly fluctuations in the particulate gross beta activity at the three stations showed seasonally dependent variations. These seasonal fluctuations are typical of fallout of stratospheric origin from previous nuclear tests.

One of the more important groups of radionuclides present in the gaseous effluents are the isotopes of iodine and particularly iodine-131 (half life, 8.05 days) which may lead to a population exposure via the pasture-cow-milk pathway. The presence of iodine-131 in air was monitored weekly at eight locations within 4 to 16 miles from the Dresden Site. Radioiodine in air is monitored by inserting charcoal cartridges behind the filters of the particulate samplers. Most of the measurements for iodine were below the minimum detectable level. However, during the second and fourth quarters slight increases in the iodine concentration were observed in many of the sampling stations. The annual mean concentration of iodine for all the sampling locations was 0.01 pCi/m³. This value is well within the limit of 0.14 pCi/m³ for iodine.[4]

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[4] The limit includes a reduction factor of 700 to the concentration limit of radioactive iodine in air of 1 × 10^{-10} µCi/cc (100 pCi/m³) in order to account for the potential environmental transfer and concentration of radioiodine in the milk-exposure pathway.

External exposures resulting from radioisotopes of the noble gases, krypton and xenon, were monitored at 18 locations within a 16-mile radius from the station. Monthly measurements were made with thermoluminescent dosimeters (TLD) and film badges while weekly measurements were made with an ion-chamber. Due to their insensitivity at low exposures, all film badge exposures were below the minimum detectable level of approximately 45 millirems. Table 12 provides a comparison between the mean annual external exposure in the vicinity of the Dresden Station to the corresponding exposures near the Quad-Cities and the Zion Stations. The annual exposure values suggest that the radioactive gaseous effluents released from the Dresden Station resulted in an increase of the external background radiation near the site.

Table 12. Summary of the mean ion-chamber measurements, onsite and offsite, 1970

Station	Number of readings	Gross external exposure	
		(mrem/week)	(mrem/a)
Dresden	774	2.1	111
Quad-Cities	732	1.8	90
Zion	147	1.8	94

The ion-chamber weekly measurements and the net increase in annual external gamma exposures are summarized in table 13. The average net increase in external exposure 2 to 16 miles from the station is indicated to have been approximately 7 millirems per year.[5] A background external exposure level of 99 millirems per year (1.9 mrem/week) was subtracted from the annual gross ion-chamber exposures,

Table 13. Summary of external gamma radiation, Dresden Nuclear Power Station, 1970[a]

Reading location	Distance from site (miles)	Ion-chamber measurements					Net exposure	
		Number of readings[b]	Maximum (mrem/week)	Minimum (mrem/week)	Mean (mrem/week)	Annual[c] (mrem)	Ion-chamber[d] (mrem/a)	TLD[e] (mrem/a)
Onsite:								
#1	NW	44	3.5	1.5	2.2	116	33	37
#2	NE	43	5.5	1.6	2.9	152	69	77
#3	S	43	3.0	1.5	2.0	107	24	33
Perimeter:								
Bennet	1 NE	42	4.0	1.5	2.1	109	26	32
Breen		43	3.0	1.8	2.2	115	32	27
Hansel	1.5 NNW	43	2.6	1.8	2.1	110	27	29
Offsite:								
Lorenzo	2.1 SSE	43	2.7	1.5	2.1	108	9	2
Clay Product	2.5 S	43	3.0	1.5	2.1	108	9	16
McCabe	2.9 WSW	43	3.0	1.5	2.0	105	6	11
Channanon	4.2 NE	42	4.5	1.0	2.0	105	6	9
Minooka	4.4 NNE	42	2.5	1.5	2.0	104	5	5
Coal City	8.0 S	44	2.5	1.5	2.0	106	7	3
Morris	8.0 SW	43	3.0	1.4	2.0	103	4	5
Elwood	8.2 E	44	3.0	1.5	2.2	113	14	7
Wilmington	8.6 SE	42	2.5	1.5	2.0	104	5	8
Lisbon	12.3 NW	43	2.8	1.5	2.0	104	5	4
Joliet	12.7 NE	44	2.5	1.5	2.1	108	9	0
Plainfield	15.7 NNE	43	3.0	1.5	2.0	102	3	5
Summary: Onsite		130	5.5	1.5	2.4	125	42	49
Perimeter		128	4.0	1.5	2.1	111	28	29
Offsite		516	3.0	1.0	2.0	106	7	6

[a] Data taken from reference 29.

[b] Reading frequency on weekly basis.

[c] Annual external radiation at each location is extrapolated for 52 weeks based on the number of readings at that location.

[d] Net ion-chamber exposure is based on the annual ion-chamber exposure minus background; background external exposure onsite and at the perimeter locations (along the Illinois River shores) is taken as 83 millirems per year. The background external exposure offsite is taken as 99 millirems per year (1.9 mrem/week) as measured during the 4th quarter of 1969 when Dresden station was not operating.

[e] Net TLD exposure measurements are sum of the quarterly TLD readings. Net readings onsite and at the perimeter locations are adjusted to account for the differences in background external radiation near the river and at locations offsite (see footnote d).

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[5] Dr. John C. Golden, staff radioecologist, Commonwealth Edison Company (in a personal communication), pointed out that the 10 mR ion chambers used by the Commonwealth Edison Company measure only gross changes in ambient gamma radiation levels. These measurements are affected by temperature, atmospheric pressure, humidity, calibration method, charge leakage, and readout error. Dr. Golden also questioned the accuracy of the TLD values (table 13). He pointed out that the TLD's are affected by the inherent radiation from the encapsulation housing and the dose accumulated during the period between the critical annealing and placement in the environs as well as the interval between the removal from the housing and readout. In light of all these variables, any net value derived from the ion-chamber and TLD measurements is of questionable reliability and validity at the low levels of exposure in the environs discussed herein.

offsite. This value is based on measurements made during the last quarter of 1969 when the Dresden Station was not operating.

An examination of the quarterly background ion-chamber measurements around the Quad-Cities and the Zion Stations indicates that the external exposures corresponding to the fourth quarter were approximately 27 percent of the annual exposures. Thus, the background external exposure of 99 millirems per year in the vicinity of the Dresden Station may be an overestimation, and consequently, the net exposure offsite may represent an underestimation of the increase in external exposure resulting from the station discharges.

The average net increases in external exposures onsite and at the perimeter locations along the Illinois River shores were approximately 46 and 29 millirems per year, respectively. These values are based on a background external exposure onsite and along the river of approximately 83 millirems per year. This background value is in accord with the findings around the Quad-Cities and the Zion Stations in which the background exposures onsite at both stations were determined to be approximately 83 millirems per year; whereas the exposures offsite were found to be approximately 98 millirems per year (tables 20 and 23).

Radioactivity in water

The environmental monitoring program of the Dresden Station included sampling of surface water, well water, precipitation and deposition. Surface water samples were collected weekly from the intake and discharge canals as well as from upstream and downstream locations. The weekly samples were analyzed for gross beta radioactivity, while quarterly and semiannual composites of the samples were analyzed for tritium. The semiannual composites were also analyzed for strontium-89 and strontium-90 concentrations. The tritium and strontium-89 measurements were at or below the minimum detectable levels, while the strontium-90 concentration was comparable to the background level found in surface water around the Quad-Cities Station.

Table 14 summarizes the gross beta analysis results for the surface water samples. The mean gross beta activity of 5.0 pCi/liter at the intake canal indicates the radioactivity from fallout and natural sources. Samples from the discharge canals of Units 1 and 2 contained additional radioactivity above the level found in the intake canal. This additional activity gives a measure of the contribution from the units' radioactive wastewater. The dilution water of Unit 2 decreased the average gross beta concentration of the surface water in the discharge canal to levels well within the range of concentrations in the upstream surface water. Considering that gross beta activity in surface water varies appreciably between influent and effluent water for normal water flow in the absence of discharges, the added activity detected at Unit 2 discharge canal was negligible. Unit 1 discharge canal mean gross beta radioactivity, however, was significantly higher than the activity in the intake water and upstream. Still, it was only about 6 percent of the annual gross beta radioactivity limit of 100 pCi/liter for an unidentified mixture of radionuclides in liquid waste.

Table 14. Summary of gross beta radioactivity in surface water, Dresden Nuclear Power Station, 1970[a]

Sampling locations	Distance from site	Number of samples	Radioactivity concentration (pCi/liter)		
			Maximum	Minimum	Mean
Intake canal	Onsite	52	28.8	ND	5.0
Discharge canal:					
Unit 1	Onsite	52	26.0	ND	11.1
Unit 2	Onsite	48	14.2	ND	5.7
Illinois River at					
Morris	10 miles downstream	24	10.4	ND	5.7
Railroad bridge	1 mile downstream	48	22.1	2.99	7.7
Gooselake	1 mile upstream	52	17.3	ND	6.2
Summary		276	28.8	ND	6.9

[a] Data taken from reference 29.
ND, nondetectable. For minimum detectable levels see table 9.

It is worth noting that the 1970 calculated gross beta concentrations at Units 1 and 2 discharge canals were 25 and 15 percent, respectively, of the unidentified mixture limit (table 8). On the other hand, the measured gross beta concentrations at the discharge canals of Units 1 and 2, as mentioned above, were considerably smaller percentages of the unidentified mixture limit. This suggests that the surface water

Table 15. Summary of gross beta radioactivity in well water Dresden Nuclear Power Station, 1970[a]

Sampling location	Distance from station (miles)	Number of samples	Radioactivity concentration (pCi/liter)		
			Maximum	Minimum	Mean
Well#1	Onsite	4	18.2	14.9	16.7
Well#2	Onsite	4	21.8	10.7	13.9
Drinking fountain	Onsite	3	16.1	13.8	15.2
Gate house	Onsite	2	18.1	15.4	16.8
Lock and Dam	[illegible].5 NW	13	15.6	8.89	12.3
Bennet	1 NE	4	15.9	6.24	9.85
Hansel	.75 NW	4	5.40	2.78	4.92
Olson	.5 SE	4	6.77	2.18	4.0
Joliet Yacht Club	1.7 NE	4	15.3	6.53	9.79
Thorsen	.5 S	4	9.07	ND	4.23
Dirker	2.1 W	4	14.3	6.01	11.8
Summary		50	21.8	ND	10.9

[a] Data taken from reference 29.
ND, nondetectable. For minimum detectable levels see table 9.

samples may not have been representative of the water in the discharge canals. A portion of the insoluable radionuclides in the liquid wastes may have been deposited immediately upon release thus resulting in a decrease in the radionuclide concentration at the point where the surface water samples were collected.[6] The surface water gross beta activity downstream, 1 mile from the Dresden Station, shows the contribution from Units 1 and 2 discharges. The mean activity of 7.7 pCi/liter was well within the river's normal background variations.

Radioactivity in precipitation and deposition was determined from samples collected weekly from two farms and from monthly samples collected onsite and 1 mile offsite. The samples were analyzed for gross beta radioactivity. The weekly and monthly gross beta measurements showed comparable concentrations. However, gross beta activity of samples at each of the stations showed wide variations with no apparent correlation to seasonal changes. Similar wide variations were observed at the Quad-Cities and Zion Stations. In view of the fact that airborne particulates monitoring around the Dresden Station did not show any abnormally high particulates activity, the elevated activity observed in some of the precipitation and deposition samples very likely reflected normal background variations.

In order to ensure detection of any ground water contamination, well-water samples were collected quarterly onsite and at seven locations offsite. All the samples were analyzed for gross beta radioactivity. Eight samples from two of the offsite locations were also analyzed for gross alpha and tritium concentrations. No tritium was detected in any of the samples. The gross alpha concentrations were within normal background range with a mean concentration of approximately 1 pCi/liter. The mean gross beta concentration of all the samples was 10.9 pCi/liter while the mean activity for the samples collected onsite was 15.3 pCi/liter (table 15). These values are relatively high in comparison to the activity found in samples collected around the Quad-Cities and the Zion Stations (table 16). In the absence of specific radionuclide analyses, the origin of the gross beta activity found in the well water samples cannot be ascertained. Past studies, however, indicated that many wells in Illinois have rela-

Table 16. Summary of the mean radioactivity in well water, 1970

Station	Number of samples	Radioactivity concentration (pCi/liter)	
		Gross alpha	Gross beta
Dresden	50	[a]1.0	10.9
Quad-Cities	36	.35	2.1
Zion	15	.5	1.3

[a] Only eight samples from two locations were analyzed for gross alpha.

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[6] Dr. John C. Golden, staff radioecologist, Commonwealth Edison Company, suggests (in a personal communication) the following additional possible explanations: (a) absorption of the soluble ions on the surface of the sediments in the discharge canals, (b) overestimation of the activity in the liquid waste, and (c) underestimation of the dilution water flow rate.

Table 17. Summary of mean radioactivity in milk, 1970

Station	Number of samples	Radioactivity concentration (pCi/liter)					Calcium (g/liter)	Strontium-90 (pCi/gCa)
		Gross beta[a]	^{89}Sr	^{90}Sr	^{137}Cs	^{131}I		
Dresden	24	627	ND	5.0	5.1	ND	1.00	5.0
Quad-Cities	24	638	ND	6.8	5.3	ND	1.11	6.1
Zion	12	NA	ND	7.3	7.4	ND	1.08	6.8

[a] Based on calibration with a strontium-yttrium standard. These figures are considered to be low because of reduced counter efficiency due to high solids absorption.
ND, nondetectable.
NA, no analysis.

tively high gross alpha and gross beta concentrations resulting from radionuclides of natural sources. Nonetheless, to place the values in perspective, the mean well water gross beta activity of 10.9 pCi/liter, assuming strontium-90 is absent, is approximately 1 percent of the applicable Public Health Service drinking water standard of 1,000 pCi/liter (*30*).

Radioactivity in foods

The environmental monitoring program of the Dresden Station included analyses of major items along the food-chain pathways. Samples of milk, vegetables, fish, forage such as grass, and other assorted cattle feed, were collected and analyzed for gross beta and specific radionuclide concentrations.

The monitoring of the pasture-cattle-milk pathway is one of the most effective ways of determining the intake level of radioiodine, radiostrontium and radiocesium. Milk, being a major dietary item, is one of the best indicator media for measurements of environmental changes in the concentrations of these radionuclides as well as other fission products. Milk samples were collected weekly from two farms. A comparison between the mean concentrations of the radionuclides found in milk collected around the Dresden Station and the corresponding concentrations in samples collected around the Quad-Cities and Zion Stations (table 17) indicates that the radioactivity in the Dresden milk samples was of natural and fallout origin with no apparent contribution attributable to the Dresden Station discharges.

Grass samples were collected monthly during the grazing season while cattle feed was collected off-season from the two farms from which the milk samples were taken. In addition, a special analysis was conducted on grass samples from five locations onsite and five offsite. Although the onsite samples generally showed higher concentrations of cesium-137 and strontium-90, their radionuclide content was within the levels found in the grass samples collected around the Quad-Cities and Zion Stations and thus reflected only background variations.

Fish samples were collected from the Kankakee and the Illinois Rivers and were analyzed for a variety of radionuclides. The results of the analyses indicated no significant difference between the samples collected upstream from the Kankakee River and downstream from the Dresden Pool, and Lock and Dam. The presence of radionuclides resulting from the possibility of selective intake and concentration in fish was monitored by gamma spectrometry. No unusually high concentration of any radionuclide was detected.

Radioactivity in other media

The radionuclides discharged in the liquid waste may accumulate in soil, slime or along the river bottom sediment which serve as integrator media for the aqueous radioactivity levels. Samples of slime and sediments were collected periodically from the inlet and discharge canals and from an upstream sampling location in the Kankakee River. Radioactivity measurements on the upstream and the inlet and discharge canals samples showed comparable levels. However, in a special analysis of the bottom sediments, the mean gross beta activity of samples collected downstream at the Dresden Pool, was approximately 14,000 pCi/

Table 18. Summary of environmental monitoring data, Dresden Nuclear Power Station, 1970[a]

Sampling media and units	Number of samples[b]	Type of analysis	Radioactivity concentration		
			Maximum	Minimum	Mean
Airborne particulates	188 (16)	Gross alpha	ND	ND	ND
(pCi/m³)	805 (16)	Gross beta	1.0	0.02	0.16
Airborne iodine-131 (pCi/m³)	403 (8)	Iodine-131	.06	ND	.01
Ion-chamber (mrem/week)	774 (18)	Gross gamma	5.5	1.0	2.1
TLD (mrem/a)	72 (18)	Net gamma	77	ND	17
Well water	8 (2)	Gross alpha	3.3	ND	1.3
(pCi/liter)	50 (11)	Gross beta	22	ND	11
	8 (2)	Tritium	ND	ND	ND
Surface water	271 (6)	Gross beta	26	ND	6.9
(pCi/liter)	[c]10 (5)	Strontium-89	ND	ND	ND
		Strontium-90	3.5	.53	2.1
	[c]20 (5)	Tritium	ND	ND	ND
Precipitation	24 (2)	Gross alpha	3	ND	.8
(pCi/liter)	128 (4)	Gross beta	490	2.0	58
Deposition (pCi/m²-week)	104 (2)	Gross beta	58,600	120	6,280
(pCi/m²-month)	24 (2)	Gross alpha	330	ND	36
		Gross beta	18,200	80	2,500
Milk	[c]24 (2)	Gross beta[d]	1,000	200	630
(pCi/liter)		Strontium-89	ND	ND	ND
		Strontium-90	11	.71	5.0
		Cesium-137	9.1	2.2	5.1
		Strontium-90[e]	12	.66	6.1
	52 (2)	Iodine-131	ND	ND	ND
Fish[f]	[g]31 (3)	Gross alpha	ND	ND	ND
(pCi/kg)		Gross beta	6.7	1.2	3.2
	5 (3)	Cobalt-60	ND	ND	ND
		Zinc-65	ND	ND	ND
		Strontium-90	1.0	ND	.35
		Cesium-137	.35	ND	.1
	31 (3)	Gamma scan[h]	ND	ND	ND
Vegetables[i] (pCi/kg)	[j]39 (3)	Gross beta	56	5	23
Cattle feed[k] (pCi/kg)	[l]16 (3)	Gross beta	11,000	1,200	4,300
		Strontium-89	ND	ND	ND
		Strontium-90	1,200	48	270
		Cesium-137	1,100	70	340
		Iodine-131	ND	ND	ND
Grass[m] (pCi/kg)	14 (2)	Strontium-89	ND	ND	ND
		Strontium-90	1,600	190	740
		Cesium-137	1,200	180	510
	[n]10 (10)	Strontium-90	1,500	300	660
		Cesium-137	340	180	240
		Iodine-131	ND	ND	ND
Slime (pCi/kg)	12 (3)	Gross beta	19,000	4,700	9,600
		Gamma scan[p]	ND	ND	ND
Soil (pCi/kg)	3 (3)	Gross alpha	830	330	600
		Gross beta	6,600	1,600	4,000
		Strontium-89	ND	ND	ND
		Strontium-90	390	30	220
		Cesium-137	870	160	480
		Gamma scan[p]	ND	ND	ND
Sediments (pCi/kg)	8 (3)	Gross beta	9,300	170	4,100
		Strontium-89	ND	ND	ND
		Strontium-90	270	11	91
		Gamma scan[p]	ND	ND	ND
	[q]15 (3)	Gross beta	14,000	560	5,900
		Gamma scan[r]	ND	ND	ND
	3 (3)	Gross alpha	6,100	4,000	4,900
		Strontium-90	400	70	200
		Cesium-137	520	460	490
		Zinc-65	1,700	ND	ND
		Cobalt-60	2,000	ND	670

[a] Data taken from reference *29*.
[b] Number in parenthesis indicates number of sampling locations.
[c] Composite samples.
[d] Based on calibration with a strontium-yttrium standard. These figures are considered to be low because of reduced counter efficiency due to solids absorption.
[e] Reporting unit is pCi of strontium-90 per gram of calcium.
[f] Results reported per edible wet weight: wet/dry weight ~ 3.8 based on reported weight for two samples.
[g] Samples included: 22 carps, 7 bullheads, 1 perch, and 1 eel.
[h] Gamma scan for potassium-40, iron-59, ruthenium-106 and thorium plus daughters.
[i] Analysis results based on wet weight: wet/dry weight ~ 11.
[j] Samples included tomatoes, cabbage, cucumbers, corn, squash, onions, melon and others.
[k] Analysis results based on dry weight: wet/dry weight ~ 1.6.
[l] Samples included ground grain, hay, silage, corn and soybeans.
[m] Analysis results based on dry weight: wet/dry weight ~ 3.2.
[n] Special analyses: wet/dry weight ~ 3.9.
[p] Gamma scan for iron-59, cobalt-60, zirconium-95, ruthenium-106, cesium-137.
[q] Special analysis: samples collected from the Kankakee River, Dresden lock and dam, and Dresden pool.
[r] Gamma scan for potassium-40, iron-59, zirconium-95, ruthenium-106, and thorium plus daughter.
ND, nondetectable. For minimum detectable levels see table 9.

kg of dry weight, whereas samples upstream showed activity of approximately 3,630 pCi/kg of dry weight. Isotopic analyses of three of the samples, one per sampling location, having the highest gross beta activity, detected the presence of zinc-65 in the downstream samples of reactor origin. The result of the special analysis suggests that the discharge canal coolant water transports and deposits at least some of the insoluble radionuclides along the bottom of the Illinois River at Dresden Pool. Since there are many factors affecting the radionuclide concentration measurements in sediments, i.e., sediment texture, water velocity, sampling location, sampling technique, etc. (*31*), it is difficult to determine from the reported data whether the accumulation of zinc-65 in Dresden Pool was significantly above background.

Table 18 provides a summary of the environmental monitoring data gathered during 1970 in the surveillance program of the Dresden Station (*29*).

Quad-Cities Nuclear Power Station

The Quad-Cities Nuclear Power Station is on the eastern shore of the Mississippi River in Rock Island County, Ill., about 140 miles west southwest of Chicago. The nearest population center is Clinton, Iowa (1960 population total, 35,700), located about 7 miles northeast of the site. Approximately 20 miles southwest of the station are the Quad-Cities: Davenport, Iowa, and Moline, East Moline and Rock Island, Ill. (1970 population total, 215,704).

The Quad-Cities Units 1 and 2 utilize two boiling water reactors, each designed to operate at a net electrical output of 809 megawatts. The units share the principal structures of the plant (i.e., reactor building, turbine building and radwaste building) and many other facilities among which are: a stack 310 feet high; a reactor building ventilation stack; a cooling water intake structure; a discharge canal structure and a radioactive liquid waste system (*32*). Neither unit was operational during 1970, thus no radioactive effluents were released to the Illinois environment during that period.

Quad-Cities Nuclear Power Station environmental monitoring program

In order to establish the background radiological conditions in the vicinity of the Quad-Cities Station and to evaluate the potential impact of thermal discharges on the Mississippi River biota and water quality, Commonwealth Edison Company conducted preoperational environmental studies beginning in 1968 and continuing through 1970. In these studies, special emphasis was placed on characterizing the aquatic biota of the Mississippi River and, in particular, of Pool 14 which will provide cooling water and dilution for the plant thermal and radioactive discharges. Samples of benthic organisms, phytoplankton, zooplankton, fish and macrophytes were collected, and their habitat and seasonal variations were studied (*33*). In addition, samples of water, air, foods and other miscellaneous media were analyzed for background radioactivity content. Table 19 summarizes the elements of the Quad-Cities environmental monitoring program (*32,34*). A brief description of the preoperational phase of this program, and a summary of the data gathered during 1970 follows.

Background environmental radioactivity

A variety of environmental media was collected and analyzed for gross radioactivity and radionuclide content. Ion-chamber gamma radiation measurements were made weekly and cumulative monthly external exposures were monitored with TLD and film badges at 16 locations around the Quad-Cities station. All of the film badge readings were below the minimum sensitivity. A summary of the ion-chamber and TLD measurements and the corresponding annual external exposures is provided in table 20. The mean radiation background for all the monitoring stations was 1.8 millirem per week which corresponds to an annual background radiation of approximately 90 millirems. This value is in good agreement with the TLD's mean annual cumulative reading of approximately 97 millirems.

It should be noted that the TLD and ion-chamber measurements onsite indicated a mean external background radiation of approximately 83 millirems per year whereas measurements

Table 19. Quad-Cities Nuclear Power Station environmental monitoring program[a]

Sample type	Number of sites	Sampling frequency	Type of analysis	Minimum detectable levels (MDL) and units[b]	
Airborne particulates	16	Weekly	Gross alpha	0.001	pCi/m^3
			Gross beta	.001	pCi/m^3
			Gamma scan		
Airborne iodine-131	8	Weekly	Iodine-131	.03	pCi/m^3
Ion-chambers	16	Weekly	Gross gamma	.6	mrem/week
TLD	16	Quarterly	Gross gamma[c]	.3	mrem/week
Well water	2	Monthly	Gross alpha	2	pCi/liter
			Gross beta	2	pCi/liter
	1	Quarterly	Gross alpha	2	pCi/liter
			Gross beta	2	pCi/liter
Surface water	4	Weekly[e]	Gross alpha	2	pCi/liter
			Gross beta	2	pCi/liter
			Strontium-89	.5	pCi/liter
			Strontium-90	.5	pCi/liter
		Quarterly	Tritium	1,000	pCi/liter
Precipitation and deposition	3	Monthly	Gross alpha	2	pCi/liter
			Gross beta	2	pCi/liter
			Gross alpha	20	pCi/m^2
			Gross beta	20	pCi/m^2
Milk	2	Monthly[e]	Iodine-131	10	pCi/liter
			Strontium-89	1	pCi/liter
			Strontium-90	1	pCi/liter
			Cesium-137	10	pCi/liter
Fish	2	4 Annually	Gross alpha	[f]2	pCi/kg
			Gross beta	[f]20	pCi/kg
			Gamma scan	[f](g)	pCi/kg
			Strontium-89	[f]5	pCi/kg
			Strontium-90	[f]5	pCi/kg
Vegetables	4	3 Annually	Gross beta	20	pCi/kg
			Strontium-89	5	pCi/kg
			Strontium-90	5	pCi/kg
			Cesium-137	10	pCi/kg
Grass	2	Monthly (April-Sept)	Gross beta	20	pCi/kg
			Strontium-89	5	pCi/kg
			Strontium-90	5	pCi/kg
			Cesium-137	10	pCi/kg
Cattle feed	2	Monthly (Oct-Nov)	Gross beta	20	pCi/kg
			Strontium-89	5	pCi/kg
			Strontium-90	5	pCi/kg
			Cesium-137	10	pCi/kg
Vegetation	16	Annually	Gross beta	20	pCi/kg
			Gamma scan	(g)	pCi/kg
			Strontium-89	5	pCi/kg
			Strontium-90	5	pCi/kg
Slime	16	Quarterly	Gross alpha	20	pCi/kg
			Gross beta	20	pCi/kg
			Gamma scan	(g)	pCi/kg
Soil	2	Annually	Gross beta	20	pCi/kg
			Gamma scan	(g)	pCi/kg
			Strontium-89	5	pCi/kg
			Strontium-90	5	pCi/kg
			Cesium-137	10	pCi/kg
Bottom sediment	4	Semiannually	Gross alpha	20	pCi/kg
			Gross beta	20	pCi/kg
		Annually	Gamma scan	(g)	pCi/kg
			Strontium-89	5	pCi/kg
			Strontium-90	5	pCi/kg
Special analysis[h]	Varies	Varies	Varies		Varies

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[a] Taken from references *32*, *34*.

[b] MDL, minimum detectable level. Since the MDL depends on factors such as analytical procedures, sample size, counting instrumentation, etc., the values given are not theoretical levels of detection but rather approximate values of sensitivity which indicate a practical minimum detection level.

[c] Beta radiation is not detected because of encapsulation of the TLD's.

[d] Composite samples.

[e] Iodine-131 analyses eliminated during winter months.

[f] pCi/kg or edible portion.

[g] MDL is a function of the complexity of the spectrum, sample size, geometry used and instrumentation.

[h] Analyses performed upon owner's request.

Table 20. Summary of external gamma radiation background, Quad-Cities Nuclear Power Station, 1970[a]

Sampling location	Distance from station (miles)	Ion-chamber measurements					TLD annual[d] (mrem)
		Number of readings[b]	Maximum (mrem/week)	Minimum (mrem/week)	Mean (mrem/week)	Annual[c] (mrem)	
Onsite:							
#1	N	47	3.5	0.7	1.6	83	80
#2	E	47	2.1	.9	1.5	80	80
#3	S	46	2.5	.8	1.8	85	90
Offsite:							
Nitrin	1.7 NE	47	2.1	1.0	1.6	85	90
Hansons boat dock	1.8 NW	47	2.2	1.2	1.7	91	110
Saddle Club dairy	1.8 SSE	47	2.3	1.0	1.8	93	90
Princeton	2.5 SW	47	2.4	1.2	1.9	97	100
Low Moor	5.9 NW	47	2.5	1.0	1.7	89	100
Sikkema Farm	6.5 ENE	47	2.5	1.0	1.8	95	100
Port Byron	8 S	47	2.2	—	1.7	88	120
Clinton	9.3 NE	29	3.0	1.3	1.9	100	110
Hillsdale	10.1 SE	47	2.3	1.0	1.7	88	100
Utica Ridge road	11.3 W	47	2.1	1.2	1.7	88	90
Erie	12.3 ESE	47	2.8	1.1	1.8	94	110
Dewitt	13.5 NW	47	2.1	.6	1.7	86	90
Bettendorf	17 SW	46	2.7	1.1	1.9	100	90
Summary: Onsite		140	3.5	0.7	1.6	83	83
Offsite		592	3.0	0.6	1.8	92	101

[a] Data taken from reference 35.
[b] Measurements taken on weekly basis.
[c] Extrapolated for 52 weeks based on number of readings at each location.
[d] Values given for annual cumulative TLD measurements.

offsite, within a radius of 17 miles, indicated a mean annual background radiation of approximately 96 millirems. These differences are likely attributable to the stations' proximity to an aquatic environment. Since the Quad-Cities site is along the Mississippi River shore, the contribution of terrestrial sources to the overall background radiation level is apparently lower onsite as compared to locations further inland.

Radioactivity levels in precipitation and deposition were determined on monthly samples. Gross beta measurements of samples collected at each of the sampling locations around the station showed comparable mean monthly values. However, as was the case for samples collected around the Dresden Station, measurements made within each location showed wide variations. For example, the gross beta concentration of precipitation, onsite, had a range of 7.4-300 pCi/m^2-month.

The preoperational environmental monitoring program included measurements of the background radionuclide concentration along the food-chain pathways. Samples of fish, vegetables, and milk, as well as grass and miscellaneous other vegetations were collected and analyzed for gross beta radioactivity and for strontium-89, strontium-90, and cesium-137 of fallout origin.

Fish samples, collected from the local market at Davenport, included a representative sample of the Missisippi River sport and commerical fish. The gross alpha, gross beta, specific radionuclides analyses and gamma spectrometry, all indicated normal background concentrations with no unusually high levels of any radionuclide due to selective metabolic concentration.

A comparison between the vegetable analysis results of the Quad-Cities and the Zion Stations shows wide differences in the radioactivity levels at the two stations. Since the results represent background radioactivity levels, it is unlikely that differences as large as three orders of magnitude are attributed to natural background variations in the radionuclide content of the soil or dry deposition at the two sites. Thus, it appears that these reported data are unreliable.[7]

In order to determine the extent to which radionuclides from the Quad-Cities Station liquid discharges will accumulate along the bottom of the Mississippi River in the vicinity of the plant, the preoperational monitoring program included analyses of slime and sediments. Samples from the inlet canal, onsite and downstream offsite, near Pool 14 Lock and Dam, were analyzed for their radionuclide constituents. The results of the inlet canal analyses are not expected to be affected by the plant liquid discharges in the operational phase of the monitoring program. Consequently, they will indicate changes in the background radioactivity of the river. Furthermore, in comparison to the downstream analytical results for slime and sediments, the inlet canal data will provide baseline values from which the extent of increase in radioactivity downstream, attributable to the plant, will be determined.

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[7] In a personal communication, Dr. John C. Golden, staff radioecologist, Commonwealth Edison Co. confirmed that the vegetable analysis results for 1970 from Dresden, Quad-Cities, and Zion stations are unreliable. More recent data collected at the three stations indicated background radioactivity concentrations of the following approximate average values: gross beta, 2,000 pCi/kg wet weight; strontium-90, 10 pCi/kg wet; cesium-137, <5 pCi/kg wet, and potassium-40, 2,000 pCi/kg wet.

Table 21 summarizes the 1970 preoperational environmental monitoring data for the Quad-Cities Nuclear Power Station (*35*).

Zion Nuclear Power Station

The Zion Nuclear Power Station is located in northeastern Illinois on the west shore of Lake Michigan, 40 miles north of Chicago and 42 miles south of Milwaukee, Wis. The station is approximately 1.7 miles east of the City of Zion (1970 population total, 17,268). It contains two pressurized water reactors each with rated net electrical output of 1,085 megawatts. Zion Units 1 and 2 will use Lake Michigan as the source for condenser cooling water and for dilution of the radioactive liquid discharges. Since the two units were under construction during 1970, they did not contribute to the environmental radioactivity in Illinois.

Zion Nuclear Power Station environmental monitoring program

During 1970, Commonwealth Edison Company, owner and operator of the Zion Station, initiated the preoperational phase of the station's environmental monitoring program. As part of this program, a special study was conducted to determine the tritium level of Lake Michigan in the vicinity of the station (*36*). In addition, an extensive survey of the lake was carried out during 1969–1970 by the Great Lakes Research Division of the University of Michigan (*6*). In this study radiochemical analyses were performed on samples of the lake biota and the lake's concentration of major radionuclides was measured. The elements of the Zion station environmental monitoring program are given in table 22 (*37*). A brief description of the preoperational monitoring program and a summary of the findings for 1970 follow.

Background environmental radiation

Ion-chamber background radiation measurements were made weekly at nine locations in and around the Zion site. A summary of these measurements is provided in table 23. The mean external background radiation for all the monitoring stations was approximately 1.8 millirem per week. Extrapolated to a full year, this corresponds to an external background radiation level of approximately 94 millirems per year. Similar to the findings around the Quad-Cities Station, the average annual external background exposure onsite was about 82 millirems whereas the corresponding value offsite was 99 millirems.

Samples of well water, precipitation and deposition were collected and analyzed monthly while surface and drinking water were analyzed weekly. The monthly samples and composites of the weekly samples were evaluated for their tritium content. None of the samples showed tritium activity above the minimum detectable level. However, in a special study of Lake Michigan surface water in the vicinity of the Zion Station (*36*), it was found that the mean tritium concentration was 340 pCi/liter with a range of 311–374 pCi/liter (table 24). Furthermore, the following conclusions were made: (a) neither seasonal variations nor depth from which water samples were taken showed a statistically significant effect on the mean tritium concentration of the lake, (b) tritium concentrations in precipitation were greater than those of the lake, with a mean value of 521 pCi/liter and a range of 172–989 pCi/liter. Similarly, the gross beta radioactivity of precipitation showed a mean radioactivity concentration of 16.6 pCi/liter as compared to the lake's surface water having mean activity level of approximately 3 pCi/liter.

Table 21. Summary of the preoperational environmental monitoring data, Quad-Cities Nuclear Power Station, 1970[a]

Sampling media and units	Number of samples[b]	Type of analysis	Radioactivity concentration		
			Maximum	Minimum	Mean
Airborne particulates (pCi/m³)	154 (3)	Gross beta	0.52	0.03	0.16
	36 (3)	Gross alpha	ND	ND	ND
Ion-chamber (mrem/week)	732 (16)	Gross gamma	3.5	.6	1.8
TLD (mrem/a)	16 (16)	Gross gamma	120	80	97
Well water (pCi/liter)	36 (5)	Gross alpha	2.0	ND	.35
		Gross beta	5.6	ND	2.13
Surface water (pCi/liter)	156 (3)	Gross alpha	.91	ND	.52
		Gross beta	6.4	2.8	4.7
	[c]12 (3)	Tritium	ND	ND	ND
	[d]6 (3)	Strontium-89	ND	ND	ND
		Strontium-90	3.52	1.90	2.55
		Tritium	ND	ND	ND
Precipitation[e] (pCi/liter)	[f]36 (3)	Gross alpha	7.35	ND	1.4
		Gross beta	300	4.8	39.1
Deposition[e] (pCi/m²-month)	[f]36 (3)	Gross alpha	990	ND	67
		Gross beta	12,600	40	1,391
Milk (pCi/liter)	24 (2)	Gross beta[g]	.960	313	683
		Strontium-89	ND	ND	ND
		Strontium-90	12.3	1.23	6.80
		Cesium-137	9.77	2.18	5.32
		Strontium-90[h]	15.4	1.17	6.40
		Iodine-131	ND	ND	ND
Fish[i] (pCi/kg)	[j]17 (1)	Gross alpha	ND	ND	ND
		Gross beta	9.9	.35	5.3
		Strontium-89	ND	ND	ND
		Strontium-90	.18	ND	.70
		Cesium-137	.70	ND	ND
		Gamma scan[k]	ND	ND	ND
Vegetables[l] (pCi/kg)	[m]29 (2)	Gross beta	70.6	5.65	27
		Strontium-89	ND	ND	ND
		Strontium-90	.18	ND	.35
		Cesium-137	.11	ND	.35
Vegetation[n] (pCi/kg)	14 (14)	Gross beta	13 [illegible]	3,640	10,500
		Strontium-89	ND	ND	ND
		Strontium-90	820	470	590
		Gamma scan[k]	ND	ND	ND
Grass[p] (pCi/kg)	24 (2)	Strontium-89	ND	ND	ND
		Strontium-90	2,370	220	1,130
		Cesium-137	1,628	170	652
Slime[q] (pCi/kg)	6 (2)	Gross alpha	2,400	380	855
		Gross beta	13,000	3,790	10,304
		Gamma scan[k]	ND	ND	ND
Soil[q] (pCi/kg)	2 (2)	Gross beta	3,370	3,300	3,335
		Strontium-89	ND	ND	ND
		Strontium-90	385	257	321
		Cesium-137	660	290	475
Sediments[q] (pCi/kg)	6 (2)	Gross alpha	1,300	320	649
		Gross beta	5,740	550	1,871
		Strontium-89	ND	ND	ND
		Strontium-90	32.8	18	23
		Gamma scan[k]	ND	ND	ND

[a] Data taken from reference *35*.
[b] Number in parentheses indicates the number of sampling locations.
[c] Quarterly composite samples.
[d] Semiannual composite samples.
[e] Samples included rain, snow and fallout deposition.
[f] Some of the samples were gamma scanned for iron-59, cobalt-60, zirconium-95, ruthenium-106, and cesium-137.
[g] Based on calibration with a strontium-yttrium standard. These figures are considered to be low because of reduced counter efficiency due to solids absorption.
[h] Reporting unit is pCi of strontium-90 per gram calcium.
[i] Results reported per edible wet weight: wet/dry weight ~ 35.
[j] Samples included buffalo, perch, carp, catfish, and bluegills.
[k] Gamma scan for iron-59, cobalt-60, zirconium-95, ruthenium-106, and cesium-137.
[l] Analyses results reported for edible wet weight: wet/dry weight ~ 12. [Data unreliable (personal communication from Dr. John C. Golden, Commonwealth Edison Co.)].
[m] Samples included tomatoes, cabbage, cucumbers, corn, onions, bell peppers and others.
[n] Analyses results based on dry weight: wet/dry ~ 3.5.
[p] Analyses results based on dry weight: wet/dry ~ 2.8.
[q] Analyses results based on dry weight.
ND, nondetectable. For minimum detectable levels see table 19.

Table 22. Zion Nuclear Power Station environmental monitoring program[a]

Sample type	Number of sites	Frequency of collection	Type of analysis	Minimum detectable levels (MDL) and units[b]
Airborne particulates	13	Monthly	Gross alpha	0.001 pCi/m^3
		Weekly	Gross beta	.001 pCi/m^3
			Gamma scan[c]	(d) pCi/m^3[d]
Airborne iodine-131	13	Biweekly	Iodine-131	.03 pCi/m^3
Ion-chambers	13	Weekly	Gross gamma	.6 mrem/week
TLD	13	Quarterly	Gross gamma[e]	.3 mrem/a
		Annually	Gross gamma[e]	.3 mrem/a
Well water	3	Quarterly	Gross alpha	2 pCi/liter
			Gross beta	2 pCi/liter
			Gamma scan[f]	(d) pCi/liter
			Strontium-89[f]	.5 pCi/liter
			Strontium-90[f]	.5 pCi/liter
			Cesium-137[f]	10 pCi/liter
			Radium-226[f]	pCi/liter
Drinking water	6	Weekly	Gross alpha	2 pCi/liter
			Gross beta	2 pCi/liter
			Gamma scan[f]	pCi/liter
		Semiannually[g]	Strontium-89	.5 pCi/liter
			Strontium-90	.5 pCi/liter
		Quarterly[g]	Tritium	1,000 pCi/liter
Surface water	5	Weekly	Gross alpha	2 pCi/liter
			Gross beta	2 pCi/liter
			Gamma scan[f]	(d) pCi/liter
		Semiannually[g]	Strontium-89	.5 pCi/liter
			Strontium-90	.5 pCi/liter
		Quarterly[g]	Tritium	1,000 pCi/liter
Precipitation and deposition[h]	3	Monthly	Gross alpha	20 pCi/m^2
			Gross beta	20 pCi/m^2
			Tritium	1,000 pCi/liter
Milk	2	Weekly[i]	Cesium-137	10 pCi/liter
		Monthly[i]	Barium-140	10 pCi/liter
			Iodine-131	10 pCi/liter
			Strontium-89	1 pCi/liter
			Strontium-90	1 pCi/liter
			Calcium	g/liter
Fish[j]	2	3 annually	Gross beta	20 pCi/kg
			Gamma scan	(d) pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Vegetables	Varies	Annually	Gross alpha	20 pCi/kg
			Gross beta	20 pCi/kg
			Gamma scan	(d) pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Grass	2	Monthly[k]	Gross beta	20 pCi/kg
			Gamma scan	(d) pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Cattle feed	2	Monthly	Gross beta	20 pCi/kg
			Cesium-137	10 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Periphyton (slime)	2	3 Annually	Gross beta	20 pCi/kg
			Gamma scan	(d) pCi/kg
Benthic organisms	2	Semiannually	Gross beta	(m) pCi/kg
			Gamma scan	(m) pCi/kg
Soil	2	Semiannually	Gross beta	20 pCi/kg
			Gamma scan	(d) pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg
Sediment	5	Semiannually	Gross alpha	20 pCi/kg
			Gross beta	20 pCi/kg
			Strontium-89	5 pCi/kg
			Strontium-90	5 pCi/kg

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[a] Taken from reference 37.

[b] MDL, minimum detectable level. Since the MDL depends on a number of factors such as analytical procedures, sample size, counting instrumentation, etc., the values specified are not theoretical levels of detection but rather approximate values of sensitivity which give an approximate level of detectability.

[c] Gamma scan performed on sample with gross beta ≥1.0 pCi/m^3.

[d] MDL is a function of the spectrum complexity, sample size, counting geometry and instrumentation.

[e] Beta radiation is not detected because of encapsulation of the TLD's.

[f] Analysis performed when gross beta >5 times the last quarterly average at the specific location from which the samples are collected.

[g] Composites of weekly samples.

[h] Rain, snow and dry fallout deposition.

[i] Weekly between April and September; monthly between October and March.

[j] Samples are split into whole and filet.

[k] Samples collected between April and September.

[m] MDL depends on size of available sample.

Table 23. Summary of external gamma radiation background, Zion Nuclear Power Station. 1970[a]

Sampling location	Distance from station (miles)	Ion-chamber measurements				
		Number of readings[b]	Maximum (mrem/week)	Minimum (mrem/week)	Mean (mrem/week)	Annual exposure[c] (mrem/a)
Onsite:						
Zion #1	0.25 S	21	2.2	1.1	1.4	75
Zion #2	.2 W	21	2.3	1.2	1.7	87
Zion #3	.5 NW	21	2.2	1.1	1.6	85
Offsite:						
Winthrop Harbor #6	2.5 N	10	2.2	1.5	1.7	90
Kenosha Road Farm #7	4 W	8	4.5	1.7	2.3	119
Waukegan #8	5 S	13	3.4	1.2	1.8	94
Zion #9	5 W	21	2.7	1.3	1.8	94
North Chicago #10	8 S	22	3.0	1.2	1.7	88
Flood Farm #12	11 SW	10	3.0	1.5	2.1	110
Summary: Onsite		63	2.3	1.1	1.6	82
Offsite		62	4.5	1.2	1.9	99

[a] Data taken from reference *38*.
[b] Sample collection frequency on weekly basis during the second half of 1970.
[c] Extrapolated for 52 weeks based on number of readings at each station.

Table 24. Summary of tritium concentration in Lake Michigan in the vincinity of Zion Nuclear Power Station, 1970[a]

Sampling location	Distance from station (feet)	Number of samples[b]	Radioactivity concentration (pCi/liter)		
			Maximum	Minimum	Mean
Kenosha water works	22,000 N	12	363	320	342
Lake County watef works[b]	2,000 NE	12	373	311	341
Surface water	660 E	12	360	315	341
12′—20′ deep	660 E	12	365	322	344
Surface water	2,000 E	12	374	321	344
22′—35′ deep	2,000 E	12	367	321	344
Surface water	6,000 E	12	367	331	347
37′—40′ deep	6,000 E	12	371	329	342
Illinois beach state park[c]	6,700 S	12	357	324	342
Waukegan water intake	32,000 S	12	359	324	342
Summary		120	374	311	343

[a] Data taken from reference *36*.
[b] Samples collected from a depth of 23 to 30 feet.
[c] Samples collected from the surface water 10 to 15 feet offshore.

Milk samples were collected monthly from two farms and analyzed for the fallout-originated radionuclides; strontium-89, strontium-90, cesium-137 and iodine-131. In addition, the potassium-40 content in milk was also determined. This radioisotope of potassium is one of the naturally occurring terrestrial sources of radiation which contributes a major portion of the internal radiation exposure to the population. Table 25 summarizes the milk analyses data as well as data from analyses of other media during 1970 as part of the preoperational environmental monitoring program (*38*).

The Lake Michigan study, sponsored by six utilities with nuclear power stations located along the lake shores, measured the level of radioactivity in the lake's water, sediments, benthos, zooplankton, phytoplankton and fish (*6*). A total of 370 samples was collected from 50 sampling stations covering the entire lake. The study provided background radiological data for evaluating the cumulative effect of the power operation of all the nuclear power stations along Lake Michigan's shores. A total of 10 nuclear power reactors is scheduled to operate by 1975 along the lake's shores and

Table 25. Summary of the preoperational environmental monitoring data, Zion Nuclear Power Station, 1970[a]

Sampling media and units	Number of samples[b]	Type of analysis	Radioactivity concentration		
			Maximum	Minimum	Mean
Airborne particulates (pCi/m^3)	129 (5)	Gross alpha	ND	ND	ND
		Gross beta	0.46	0.03	0.13
Airborne iodine-131 (pCi/m^3)	11 (5)	Iodine-131	.03	ND	.01
Ion-chamber (mrem/week)	147 (9)	Gross gamma	4.5	1.1	1.8
Well water (pCi/liter)	15 (3)	Gross alpha	4.3	ND	.5
		Gross beta	7.8	ND	1.3
		Tritium	ND	ND	ND
Surface water (pCi/liter)	95 (4)	Gross alpha	5.3	ND	.5
		Gross beta	11	ND	2.9
	[c]23 (4)	Tritium	ND	ND	ND
Drinking water (pCi/liter)	102 (5)	Gross alpha	4.6	ND	.3
		Gross beta	11	ND	2.4
	[c]30 (5)	Tritium	ND	ND	ND
Precipitation (pCi/liter)	16 (3)	Gross alpha	7.4	ND	.5
		Gross beta	48	ND	16.6
		Tritium	ND	ND	ND
Deposition (pCi/m^2-month)	16 (3)	Gross alpha	48	ND	3
		Gross beta	2,000	ND	264
Milk (pCi/liter)	12 (2)	Potassium-40	2,140	1,070	1,500
		Strontium-89	ND	ND	ND
		Strontium-90	15.4	3.61	7.33
		Cesium-137	16.5	3.49	7.40
		Iodine-131	ND	ND	ND
		Strontium-90 [d]	13.7	1.23	6.41
Vegetables[f] (pCi/kg)	[e]9 (3)	Gross alpha	3,700	ND	766
		Gross beta	34,000	14,000	21,600
		Strontium-90	800	140	430
Feedcrops[g] (pCi/kg)	[h]3 (3)	Strontium-89	ND	ND	ND
		Strontium-90	170	100	140
		Cesium-137	380	170	260
Grass[i] (pCi/kg)	19 (12)	Strontium-89	ND	ND	ND
		Strontium-90	1,530	190	840
		Cesium-137	1,010	190	540
Slimes[g] (pCi/kg)	4 (4)	Gross alpha	840	350	578
		Gross beta	8,090	4,040	5,805
		Gamma scan	ND	ND	ND
Soil[g] (pCi/kg)	3 (3)	Gross alpha	2,300	1,600	1,900
		Gross beta	6,000	1,600	3,500
		Strontium-89	ND	ND	ND
		Strontium-90	386	270	319
		Cesium-137	780	360	520
		Gamma scan	ND	ND	ND
Sediments[g] (pCi/kg)	[j]3 (1)	Cesium-137	230	ND	133
		Radium-226	2,060	1,400	1,720
		Potassium-40	9,610	8,490	8,990

[a] Data taken from reference *38*.
[b] Number in parentheses indicates number of sampling locations.
[c] Monthly composite samples.
[d] Reporting unit is pCi of strontium-90 per gram of calcium.
[e] Analysis results based on dry weight: wet/dry ~ 19. [Data unreliable (personal communication from Dr. John C. Golden, Commonwealth Edison Co.)].
[f] Samples included tomatoes, onions, green beans, and cabbage.
[g] Analyses results based on dry weight.
[h] Samples included corn and soybeans.
[i] Analysis results based on dry weight: wet/dry ~ 3.5.
[j] Sampled during the Lake Michigan Study (*6*) at a sampling station 1-mile east of the Zion Station
ND, nondetectable. For minimum detectable levels see table 22.

use the lake's water for dissipating excess heat and for diluting radioactive waste discharges.

Among the findings of the Lake Michigan study, it is worth noting that the fish analyzed showed cesium-137 and zinc-65 concentrations far greater than those found in the water. Concentration factors ranged from 100 to 900 for cesium-137 and from 40 to 30,000 for zinc-65.[*] This points out a potentially important

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[*] Dr. John C. Golden, staff radioecologist, Commonwealth Edison Co., in a personal communication pointed out that a reexamination of the gamma-ray spectra by the authors of the original report showed that zinc-65 was not present in the fish. The reported values in the report are believed to represent residual counts after spectrum stripping.

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source of population exposure via the food-chain pathway. In addition, it was found that an estimated two-thirds of the lake's inventory of cesium-137 is concentrated in the bottom sediments having a concentration of 1.4 pCi/g dry weight. Other media such as benthic organisms and phytoplankton also showed reconcentration factors, but of considerably lower levels.

Other radiation sources

As mentioned earlier in this report, the major manmade source of radiation exposure to the population is from medical uses of x-ray devices. Table 26 gives the estimated number of dental and medical x-ray units in Illinois for 1970 (*39*). It also provides the estimated number of a variety of other radiation sources utilized by educational and governmental laboratories and by industry. The sundry other sources are generally located in a controlled access area. The exposure from these sources is limited almost entirely to the individuals using them and contribute primarily to occupational radiation dose.

The seven reactors referred to in table 26 include six reactors of various types located at the Argonne National Laboratory (ANL) (table 27) and one reactor operated by the University of Illinois.

Table 26. Miscellaneous radiation sources in Illinois, 1970[a]

Type of facility	Estimated number of units
Dental x ray	5,544
Medical x ray:	
Diagnostic	4,103
Therapeutic	347
Industrial x ray	473
Particle accelerators	17
Byproducts, source and special nuclear material licenses	677
Radium—Radon program activities	56
Miscellaneous reactors	7

[a] Data taken from reference *39*.

As mentioned earlier, results of the environmental surveillance program in and around the Argonne National Laboratory are reported semiannually (*4*) and summarized in *Radiation Data and Reports* (*2,3*). The 1970 data indicates that Argonne's contribution to the environmental radioactivity, offsite, was limited primarily to an increase in the tritium concentration of the Sawmill Creek water and the Des Plaines River in the immediate vicinity of the laboratory. Sawmill Creek is a stream that flows through the laboratory site into the Des Plaines River. The increase in the tritium level offsite resulting from the Argonne's discharges was a small fraction (less than 0.02 percent) of the applicable AEC limit. From the standpoint of population exposure, the ANL discharges contributed primarily to occupational exposure.

Table 27. Nuclear facilities at Argonne National Laboratory, 1970[a]

Name of facility	Reactor type	Power kW(t)	Year of startup
Argonne Research Reactor	Heavy water	5,000	1954
Argonne National Laboratory	Homogeneous solid	Negligible	1957
Argonne Nuclear Assembly[b]	Graphite/water	10	1957
Argonne Thermal Source Reactor	Thermal	10	1957
Biological Research Reactor	Tank	200	1964
Argonne Power Research Reactor	Graphite/water	250	[c]1962

[a] Taken from reference *39*. The reactors are owned by the Atomic Energy Commission.
[b] For University training.
[c] Shut down during 1970.

The seventh reactor in the state is an advanced TRIGA research reactor with a rated maximum power of 1.5 megawatt owned by the University of Illinois and located on campus in Urbana, Ill. The limiting radionuclide discharged from this type of facility is argon-41 which is a beta emitter having a 1.8 hour half-life. It is produced by neutron activation of stable argon-40, a natural constituent of the atmosphere. Based on experience gained from nine college-based TRIGA research reactors, radioactive wastes discharged from these low power facilities are generally less than 1 curie per year and do not contribute significantly to the general population exposure (*40*).

Population exposure in Illinois

In the 1968 special study of the Dresden Unit 1 effluents (*9*), the critical exposure pathway was determned to be via external radiation from the short-lived isotopes of the radioactive noble gases, krypton and xenon. Similarly, the 1970 results of the Dresden Station environmental monitoring program indicated that external exposure from the station's gaseous discharges was the major contributor to the population dose in the vicinity of the station. The average annual increase in dose from external exposure, offsite, 1 to 2 miles from the station, was approximately 29 millirems, while the corresponding increase at locations 2 to 16 miles from the station, based on ion-chamber and TLD measurements, was about 7 millirems. The exposure pathway via external radiation from the gaseous effluents was the only pathway for which direct measurements yielded estimated exposure values. Radioactivity levels along other potential exposure pathways were either below detectable limits or indicated contributions of radionuclides from natural and fallout origins. In the few instances where the measurements indicated the presence of radionuclides of reactor origin, the measured increases in radioactivity were marginally above background.

Blanchard et al. (*21,41*) calculated the maximum potential dose in the vicinity of the Dresden Station via seven principal pathways. The dose rate calculations were based on the radionuclide release rates measured in the stack during 1968 and the concentrations measured in the condenser coolant discharge canal (*9*). Each pathway was considered individually for the major radionuclides found in the effluents and the dose resulting from each nuclide was estimated. The exposure pathways originating from the stack discharges included the ingestion of milk, beef, and leafy vegetables, inhalation of airborne halogens and particulates and the external exposure pathway. The two pathways whose radionuclides originated from the liquid discharges were drinking water and ingestion of fish.

In order to provide a measure of the relative importance of the principal exposure pathways for which direct measurements were not available, and to identify the critical radionuclides for each of these pathways, the estimated maximum potential dose during 1970 from the critical radionuclides to an individual offsite is given in table 28. The estimated dose rates (dose from external exposure excluded) are calculated from values estimated by Blanchard et al. In arriving at the dose rates for 1970 it was assumed that the pathways, the transfer coefficients, and dilution factors used in calculating the 1968 estimated dose rates were applicable to the discharges of 1970. In addition, it was assumed that the gaseous and liquid effluents radionuclide composition as well as the relative contribution of each nuclide to the total activity were similar in 1970 to the corresponding values measured during 1968. In light of these assumptions and the nature of the original dose estimates, the values for 1970 are meaningful only as indicators of the relative importance and order of magnitude of the dose rates from the critical radionuclide in each of the pathways. The estimated values represent upper limits of potential dose rates to an individual offsite as a result of the Dresden Station discharges. In five of the pathways, iodine-131 is found to be the critical radionuclide. In the case of exposure via the consumption of beef, cesium-137 is found to be the critical nuclide.

Table 29 summarizes the estimated annual dose to the critical organs, for the major radionuclides in the Dresden effluents. It also summarizes the percentages of the critical organs' annual dose relative to the Radiation Protec-

Table 28. Maximum potential dose from critical radionuclides in each pathway, 1970[a]

Pathway	Critical radionuclide	Critical organ	Estimated dose rate (mrem/a)
Atmosphere-external	Gaseous fission products	Whole body	[b]32
Milk	Iodine-131	Thyroid	31
Leafy vegetable	Iodine-131	Thyroid	7.2
Drinking water	Iodine-131	Thyroid	3.2
Fish	Iodine-131	Thyroid	.4
Beef	Cesium-137	Whole body	.033
Atmosphere-inhalation	Iodine-131	Thyroid	.013

[a] Estimated dose rates are calculated based on estimated values in references *21, 41*.

[b] Value based on the gaseous effluents discharged during 1970.

Table 29. Estimated annual dose to critical organs, 1970

Critical organ	Estimated dose (mrem/a)	RPG[a] (mrem/a)	Percent of RPG
Whole body-external	32	170	18
Thyroid	42	500	8
Bone	.54	170	.3
Whole body-internal	.34	170	.2
GI (LLI)[b]	.07	[c]500	.01

[a] RPG, Radiation Protection Guide (*42*).

[b] GI (LLI), gastrointestinal tract (lower large intestine).

Value based on International Committee on Radiation Protection (ICRP) (*43*).

tion Guide (*RPG*) (*42*) dose limits. Since no person is likely to be exposed to all the pathways, the estimated values represent maximum dose levels and indicate the relative dose rates for the various critical organs. Results indicate that the whole body receives the greatest percentage of the RPG annual dose limit.

The contribution to the population exposure from all natural and manmade sources is summarized in table 30 (*44*). The dose values corresponding to the natural radiation from external sources are based on calculations by Oakley (*45*) in which the natural radiation exposure in the United States was estimated from the Aerial Radiological Measurement Surveys (ARMS) conducted by the Atomic Energy Commission over major areas of the United States. The population exposure from natural external radiation in Illinois was based on measurements taken at 12 population centers with a total of more than 10,081,000 people. The exposures in the study were weighted by the population at each of the survey areas. The average dose from natural external radiation of approximately 90 millirems per year estimated by Oakley is in good agreement with the ion-chamber external background measurements taken during the preoperational surveillance program of the Quad-Cities and the Zion Stations (tables 20 and 23).

Table 30. Estimated average annual genetically significant dose to the population in Illinois, 1970

Source of radiation	Annual dose[a] (mrem/a)	Percent of natural radiation
Natural radiation		
External sources:		
Terrestrial gamma radiation	[b]43	37
Cosmic radiation	[b]47	41
Internal sources:		
Potassium-40	17	15
Carbon-14	1	.9
Rubidium-87	.6	.5
Polonium-210	3	2.6
Radon-222	3	2.6
Subtotal (rounded)	115	100
Residual fallout from nuclear tests:		
Cesium-137	1.3	1.1
Carbon-14	.6	.5
Strontium-90	3.2	2.8
Subtotal	5.1	4.5
Medical uses of radiation:		
Medical and dental radiology	55	48
Radiation therapy	5	4.4
Radiopharmaceutical use	[c]1.2	1
Subtotal (rounded)	61	53
Occupational	~1	.9
Miscellaneous other sources[d]	2	1.7
Total	184	160
Residents, Dresden vicinity, <16-miles	7	6.1

[a] Annual dose values are taken from reference *44*, except as noted.
[b] Values based on reference *45*.
[c] Value taken from reference *46*.
[d] Miscellaneous other sources include: radiation from TV, luminous dials, commercial appliances, air transportation, etc.

To place the various manmade sources of radiation in perspective, the percentages of the annual dose from each source relative to the total dose from natural radiation are tabulated. It is worth noting that the increase in the genetically significant dose from manmade sources is approximately 60 percent of the dose corresponding to natural background. The major portion of this increase (approximately 53 percent), is due to medical uses of radiation. For the special case of the population within 16 miles from the Dresden Station, totaling approximately 150,000 people, there was an apparent additional increase during 1970 in the whole body genetically significant dose, above the dose from natural radiation, of approximately 6 percent attributable to the Dresden Station discharges.

Summary and conclusions

Dresden Nuclear Power Station Units 1 and 2 were the only power reactors operating in Illinois during 1970. Dresden Station Unit 3, Quad-Cities Station Units 1 and 2, and Zion Station Units 1 and 2 were under construction during this period. They are all scheduled to be operational by 1973.

Based on ion-chamber and TLD measurements made in the preoperational environmental monitoring programs of the Quad-Cities and Zion Stations, the average background external exposure onsite, at both stations, was approximately 83 millirems per year. The corresponding average value, offsite, was about 98 millirems per year.

Dresden Unit 1 average annual release of noble and activation gases for the past 11 years was approximately 390,000 curies per year, which is 2.2 percent of the plant technical specification limit. For the same period Unit 1 average annual release via the liquid waste was 5.5 curies per year or 17 percent of the applicable limit. The releases of radioactivity from Unit 1 during 1970 suggest that the plant discharges leveled off after reaching a peak in

1969. Dresden Unit 2 in its first year of operation discharged 12.8 curies via the liquid waste and 250,000 curies via the gaseous waste. These correspond to 15 and 1.1 percent, respectively, of the plant technical specification limits.

A comparison between the radioactivity levels in environmental media near the Dresden Station and the background radioactivity levels measured in the preoperational phases of the Quad-Cities and Zion Stations indicated that the effect of the Dresden discharges on most environmental media was scarcely distinguishable from the radioactivity resulting from fallout of atmospheric nuclear tests and from natural sources. The only apparent increase in environmental radioactivity attributable to the Dresden Station operations during 1970 was an approximately 6 percent increase in the radiation dose in the vicinity of the station relative to the natural background radiation in Illinois of 115 millirems per year.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, July 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveilance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the network presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostron-

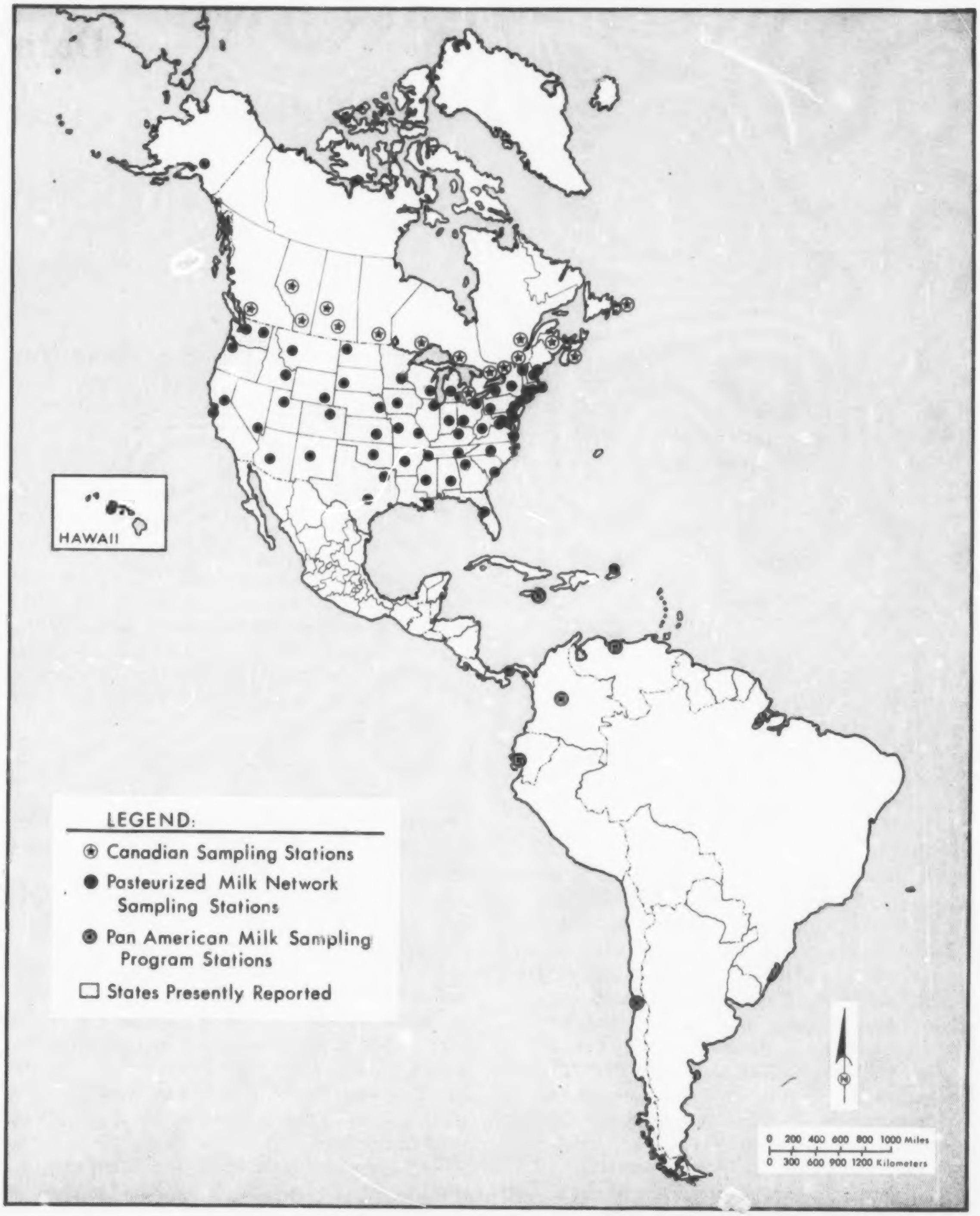
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

tium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accurary results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2 standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter: 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated

Table 2. Concentrations of radionuclides in milk for July 1972 and 12-month period August 1971 through July 1972

Sampling location		Type of sample	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	5	7	0	9
Alaska:	Palmer[c]	P	4	5	11	11
Ariz:	Phoenix[c]	P	0	0	[illegible]	0
Ark:	Little Rock[c]	P	10	12	0	8
Calif:	Sacramento[c]	P	0	1	0	0
	San Francisco[c]	P	0	1	0	0
	Del Norte	P	13	12	0	11
	Fresno	P	0	2	0	5
	Humboldt	P	3	4	0	8
	Los Angeles	P	0	2	0	5
	Mendocino	P	5	5	0	7
	Sacramento	P	0	2	0	6
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	7
	Shasta	P	2	3	0	8
	Sonoma	P	2	2	0	7
Colo:	Denver[c]	P	7	5	0	4
	East	R	NS		NS	[d]0
	Northeast	R	NA		[d]0 (2)	[d]0
	Northwest	R	NA		[d]0	[d]0
	South Central	R	NS		NS	
	Southeast	R	NA		[d]0	[d]0
	Southwest	R	NA		[d]0	[d]0
	West	R	NA		[d]0	5
Conn:	Hartford[c]	P	7	6	21	8
	Central	P	8	7	10	13
Del:	Wilmington[c]	P	11	8	14	6
D.C:	Washington[c]	P	8	7	13	6
Fla:	Tampa[c]	P	4	5	41	40
	Central	R	7	6	54	40
	North	R	5	10	10	19
	Northeast	R	3	6	32	34
	Southeast	R	6	6	34	56
	Tampa Bay area	P	4	6	37	37
	West	R	4	9	7	18
Ga:	Atlanta[c]	P	8	9	14	14
Hawaii:	Honolulu[c]	P	0	3	0	2
Idaho:	Idaho Falls[c]	P	[illegible]	5	0	0
Ill:	Chicago[c]	P	3	6	12	11
Ind:	Indianapolis[c]	P	3	6	0	3
	Central	P	6	7	0	12
	Northeast	P	6	7	0	12
	Northwest	P	8	8	0	15
	Southeast	P	9	8	0	13
	Southwest	P	9	9	15	13
Iowa:	Des Moines[c]	P	5	4	0	1
	Iowa City	P	6	7	15	10
	Des Moines	P	6	6	12	10
	Little Cedar	P	NS	6	NS	6
	Spencer	P	6	7	11	12
Kans:	Wichita[c]	P	8	8	0	1
	Coffeyville	P	7	8	0	12
	Dodge City	P	7	5	0	9
	Falls City, Nebr	R	6	3	11	8
	Hays	P	7	9	0	8
	Kansas City	P	6	8	0	11
	Topeka	P	7	7	0	9
	Wichita	P	8	9	0	9
Ky:	Louisville[c]	P	7	8	0	8
La:	New Orleans[c]	P	16	14	11	11
Maine:	Portland[c]	P	6	6	18	20
Md:	Baltimore[c]	P	7	7	0	4
Mass:	Boston[c]	P	9	7	13	11
Mich:	Detroit[c]	P	7	7	0	9
	Grand Rapids[c]	P	6	7	0	7
	Bay City	P	NS	5	NS	13
	Charlevoix	P	4	8	16 (4)	14
	Detroit	P	4	5	0	10
	Grand Rapids	P	NS	5	NS	10
	Lansing	P	6	7	0	12
	Marquette	P	3	7	12 (3)	22
	Monroe	P	3	3	0 (3)	4
	South Haven	P	5	5	13 (4)	9
Minn:	Minneapolis[c]	P	8	8	16	15
	Bemidji	P	5	8	13	19
	Duluth	P	12	16	31	28
	Fergus Falls	P	6	8	13	16
	Little Falls	P	26	17	123	38
	Mankato	P	4	5	8	12
	Minneapolis	P	8	12	14	17

Footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for July 1972 and 12-month period August 1971 through July 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:—continued						
Minn:	Rochester	P	6	8	12	14
	Worthington	P	5	6	11	12
Miss:	Jackson[c]	P	8	10	11	10
Mo:	Kansas City[c]	P	7	7	0	5
	St. Louis[c]	P	6	7	11	5
Mont:	Helena[c]	P	6	5	0	5
Nebr:	Omaha[c]	P	4	5	0	2
Nev:	Las Vegas[c]	P	3	2	0	0
N.H:	Manchester[c]	P	8	8	15	17
N.J:	Trenton[c]	P	6	7	0	5
N. Mex:	Albuquerque[c]	P	0	2	0	0
N.Y:	Buffalo[c]	P	7	6	[d]0	7
	New York City[c]	P	12	8	[d]0	8
	Syracuse[c]	P	6	7	[d]0	8
	Albany	P	6	6	[d]0 (3)	[d]0
	Buffalo	P	NA		11	[d]0
	Massena	P	NA		[d]0	[d]0
	New York City	P	NA		13	0
	Syracuse	P	0	3	0	0
N.C:	Charlotte[c]	P	10	10	0	8
N. Dak:	Minot[c]	P	10	9	14	14
Ohio:	Cincinnati[c]	P	7	7	0	3
	Cleveland[c]	P	6	6	0	6
Okla:	Oklahoma City[c]	P	5	6	0	6
Oreg:	Portland[c]	P	NA	5	18	6
	Baker	P	4	1	[d]0	[d]0
	Coos Bay	P	6	1	[d]0	3
	Eugene	P	3	0	[d]0	1
	Medford	P	NS	1	[d]0	4
	Portland composite	P	7	1	18	6
	Portland local	P	8	2	[d]0	8
	Redmond	P	4	1	[d]0	[d]0
	Tillamook	P	9	1	20	12
Pa:	Philadelphia[c]	P	8	7	0	5
	Pittsburgh[c]	P	10	9	14	6
	Dauphin	P	5	7	0	12
	Erie	P	10	7	13	12
	Philadelphia	P	6	5	0	12
	Pittsburgh	P	8	6	18	14
R.I:	Providence[c]	P	5	6	15	11
S.C:	Charleston[c]	P	7	9	14	14
S. Dak:	Rapid City[c]	P	8	7	0	5
Tenn:	Chattanooga[c]	P	11	8	11	9
	Memphis[c]	P	NA	7	0	3
	Chattanooga	P	11	10	22	13
	Clinton	R	9	9	0	12
	Fayetteville	R	10	9	10 (2)	6
	Kingston	R	8	9	14 (2)	9
	Knoxville	P	8	8	12 (2)	10
	Lawrenceburg	R	7	8	18	9
	Nashville	P	7	8	0	7
	Pulaski	R	7	7	6 (2)	8
Tex:	Austin[c]	P	7	3	0	0
	Dallas[c]	P	6	6	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[c]	P	3	4	11	5
Vt:	Burlington[c]	P	8	6	11	10
Va:	Norfolk[c]	P	9	8	0	6
Wash:	Seattle[c]	P	9	5	0	5
	Spokane[c]	P	4	5	11	8
	Benton County	R	0	1	0	0
	Franklin County	R	NS	1	NS	2
	Longview	R	6		0	
	Sandpoint, Idaho	R	14	12	14	18
	Skagit County	R	9	8	12	6
W. Va:	Charleston[c]	P	10	8	15	5
Wisc:	Milwaukee[c]	P	4	5	0	6
Wyo:	Laramie[c]	P	5	4	0	2

Footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1972 and 12-month period August 1971 through July 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:						
Alberta:	Calgary	P	NA		11	17
	Edmonton	P	NA		28	26
British Columbia:						
	Vancouver	P	NA		18	25
Manitoba:	Winnipeg	P	NA		17	22
New Brunswick:						
	Fredericton	P	NA		NA	
Newfoundland:						
	St. John's	P	NA		39	27
Nova Scotia:						
	Halifax	P	NA		21	22
Ontario:	Ottawa	P	NA		10	12
	Sault Ste. Marie	P	NA		22	29
	Thunder Bay	P	NA		17	22
	Toronto	P	NA		12	12
	Windsor	P	NA		10	9
Quebec:	Montreal	P	NA		13	15
	Quebec	P	NA		27	27
Saskatchewan:						
	Regina	P	NA		13	17
	Saskatoon	P	NA		17	17
CENTRAL AND SOUTH AMERICA:						
Canal Zone:						
	Cristobal[c]	P	3	1	28	9
Chile:	Santiago	P	6	1	12	2
Colombia:	Bogota	P	0	1	0	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Kingston	P	0	4	26	[illegible]6
Puerto Rico:						
	San Juan[c]	P	0	3	0	7
Venezuela:	Caracas	P	2	1	0	0
PMN network average[e]			6	6	6	7

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels.:

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for July 1972 and the 12-month period, August 1971 to July 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140

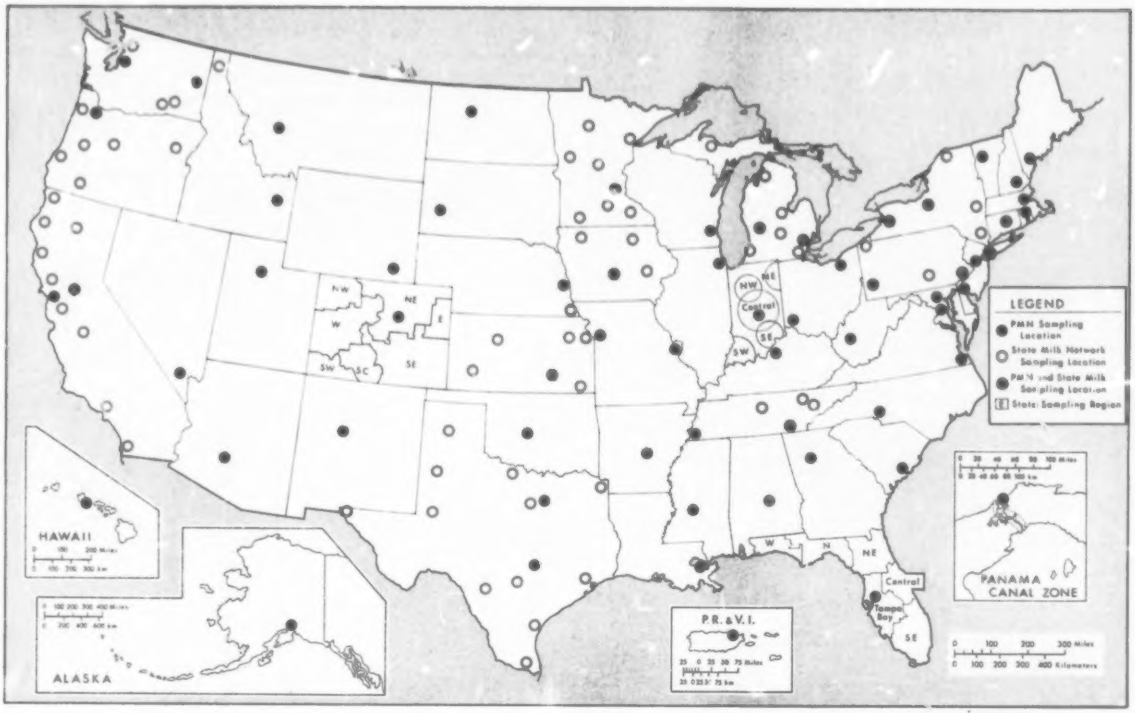
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
E State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

data have been omitted from table 2 since levels at the great majority of the stations for July 1972 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for July 1972 and the highest 12-month average was 17 pCi/liter (Little Falls, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 123 pCi/liter in the United States for July 1972, and the highest 12-month average was 56 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (7) and Jamaica.

Table. 3. Strontium-89, iodine-131, and barium-140 in milk,[a] July 1972

Sampling location		Concentration (pCi/liter)
		Strontium-89
Chile:	Santiago (PAHO)	15
Del:	Wilmington (PMN)	7
D.C:	Washington (PMN)	6
Kans:	Dodge City (State)	6
	Hays (State)	6
	Kansas City (State)	5
Mass:	Boston (PMN)	6
Nebr:	Omaha (PMN)	9
N.J:	Trenton (PMN)	6
N.Dak:	Minot (PMN)	6
Pa:	Pittsburgh (PMN)	11
R.I:	Providence (PMN)	7
S. Dak:	Rapid City (PMN)	9

[a] Iodine-131 and barium-140 were nondetectable during July 1972.

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July–December 1970	November 1971
Carbon-14 in Total Diet and Milk	July–December 1971	May 1972
Connecticut Standard Diet	January–December 1970	December 1971
Institutional Total Diet	October–December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January–December 1970	April 1972
Strontium-90 in Tri-City Diets	January–December 1970	November 1971

Radiostrontium in milk, January-December 1971

Health and Safety Laboratory[1]
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring for strontium-90 in liquid whole milk to estimate the dietary contribution from the ingestion of the radionuclide from this source.

The New York City sample is a monthly composite of pasteurized milk purchased daily at retail stores. Five main dairies are represented in the sample. The powdered milk sampling at Perry, N.Y. was terminated at the end of 1969.

The strontium-90 to calcium ratios for New York City for January–December 1971 is presented in table 1.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1970	April 1972

Table 1. Strontium-90 to calcium ratios in milk, January-December 1971

Sampling location	Strontium-90 to calcium ratio (pCi/g)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y.	7.3	8.5	6.6	8.5	9.2	10.3	8.8	7.3	7.6	6.2	6.0	6.1

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[1] Data summarized from "Fallout Program Quarterly Summary Report," HASL-257, July 1, 1972, available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
Colorado River Basin	1968	March 1972
Community Water Supply Study,	1969	September 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1970	December 1971
Michigan	January–June 1970	November 1971
North Carolina	1968–1970	September 1972
Radioactivity in California Waters	January–December 1970	June 1972
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, *HASL*	January–June 1971	April 1972
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January–March 1972	August 1972
Washington	July 1969–June 1970	March 1972
New York	July–December 1970 and January–June 1971	May 1972

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Gross Radioactivity In Surface Waters of the United States March 1972

Office of Air and Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Air and Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, this activity was resumed as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from 22 rivers and the Great Lakes during March 1972. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/Liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

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Table 1. Gross radioactivity in U.S. surface waters, March 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Allegheny River:					
Pittsburgh, Pa	1	<0.3	<0.6	<2	5
Animas River:					
Durango, Colo	1	<.4	1.4	2	5
Beaver River:					
New Brighton, Pa	1	<.4	<1.0	2	10
Cheyenne River:					
Edgemont, S. Dak	1	3.2	3.1	25	10
Clinch River:					
Kingston, Tenn	4	.4 <.3 <.4 <.2	.5 <.5 <.5 <.4	<2 <2 <2 <2	4 6 7 9
Colorado River:					
DeBeque, Colo	1	.8	4.4	5	15
Moab, Utah:					
Highway Bridge	4	8.4 5.5 2.3 1.0	8.2 6.5 5.5 6.8	24 28 9 7	19 10 16 18
Above Mill Creek	4	7.5 7.4 2.2 2.1	6.1 6.8 3.9 20.6	19 29 14 6	11 17 23 42
Silt, Colo	1	.8	2.1	9	17
Cuyahoga River:					
Cleveland, Ohio	1	<.3	<1.4	3	10
Dolores River:					
Bedrock, Colo	5	3.6 8.1 11.3 4.7 2.4	4.5 2.0 1.8 3.4 3.0	12 29 32 16 8	9 <5 <4 12 14
Gateway, Colo	5	7.5 8.0 12.8 5.4 3.2	10.4 9.2 3.6 3.2 3.3	25 28 34 39 11	67 32 9 15 26
Great Lakes:					
Lake Erie:					
Buffalo, N.Y	1	<.5	<.3	<3	3
Green River:					
LaBarge, Wyo	1	.7	1.5	6	11
Kanawha River:					
Winfield Dam, W. Va	1	1.7	<1.1	4	4
Maumee River:					
Toledo, Ohio	1	1.0	1.3	4	6
Mississippi River:					
Burlington, Iowa	1	1.4	.9	3	7
Missouri River:					
Omaha, Nebr	1	1.0	4.5	5	9
Monongahela River:					
Pittsburgh, Pa	2	<.4	<.8	2	5
Muskingum River:					
Lock and Dam #2	1	<.4	<2.1	2	9
North Platte River:					
Henry, Nebr	1	<.4	16.8	7	31
Ohio River:					
Addison, Ohio	1	1.7	<.7	9	5
Cincinnati, Ohio	5	10.9 3.0 .6 3.7 1.1	.6 .9 .4 <.5 <.2	28 8 4 17 6	2 2 5 8 4
Hancock, W. Va	1	.7	<1.3	2	5
Marietta, Ohio	1	<.4	<.8	3	7
New Martinsville, W. Va	1	.6	.8	2	4
Old Lock #19, W. Va	1	.4	<.7	<2	4
Warwood, W. Va	1	<.4	<.7	2	5
Platte River:					
Plattsmouth, Nebr	1	2.9	10.3	6	27
Roanoke River:					
John Kerr Dam, Va	4	.7 .5 <.4 <.2	<.4 <.4 <.4 <.2	<2 <2 3 4	2 <2 2 6
San Miguel River:					
Uravan, Colo	5	.6 .3 .8 .8 <.2	7.7 4.5 <1.4 3.4 1.8	2 5 6 5 4	11 12 7 8 12
Below Uravan, Colo	5	2.6 .6 .8 <.2 .3	1.18 12.0 11.0 6.5 18.1	8 3 <2 3 4	26 27 18 18 20

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Table 1. Gross radioactivity in U.S. surface waters, March 1972—continued

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
San Miguel River: (cont.)					
Naturita, Colo.	5	.9	5.7	4	10
		2.5	3.7	5	8
		.9	1.2	4	6
		<.3	1.2	2	11
		<.2	1.8	4	12
St. Lawrence River:					
Massena, N.Y.	4	<.4	<.7	<2	4
		.7	.9	<2	5
		.3	.4	<2	5
		<.2	<.4	2	6
Virgin River:					
St. George, Utah	1	7.9	19.1	27	36

Radioactivity in Minnesota Municipal Water Supplies[1] July 1970–June 1971

Division of Environmental Health
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Environmental Health Program in the Minnesota Department of Health. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul. Beginning in November 1969, weekly samples from these stations were composited and analyzed on a monthly basis. Monthly samples are taken at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is evaporated into a 2-inch aluminum milk-bottle-lid planchet and counted in a proportional-gas-flow counter. The counter is calibrated with cesium-137/uranium-238 standards.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from July 1970–June 1971. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 2 to 29 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

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[1] Data and information from "Survey of Environmental Radioactivity, July 1970–June 1971." Publication No. C00-651-86. State of Minnesota Department of Health, University Campus, Minneapolis, Minn. 55440.

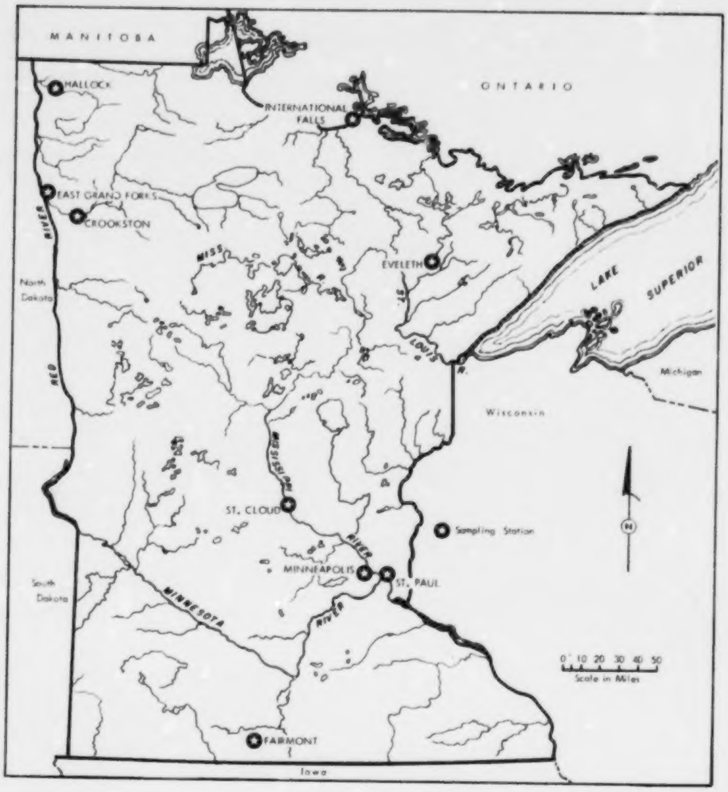
MANITOBA
ONTARIO
HALLOCK
INTERNATIONAL FALLS
EAST GRAND FORKS
CROOKSTON
RED RIVER
North Dakota
MISS
EVELETH
ST. LOUIS R.
LAKE SUPERIOR
Michigan
Wisconsin
MISSISSIPPI RIVER
ST. CLOUD
Sampling Station
N
MINNEAPOLIS
ST. PAUL
South Dakota
MINNESOTA RIVER
0 10 20 30 40 50
Scale in Miles
FAIRMONT
Iowa

Figure 1. Minnesota surface water sampling locations

Table 1. Average gross beta radioactivity in Minnesota raw and treated water supplies, July 1970-June 1971

Town and water source	Type of water	Average concentration (pCi/liter)											
		1970						1971					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	26	21	22	21	14	20	18	14	18	18	20	15
	Treated	20	14	17	19	14	18	18	19	14	19	14	12
East Grand Forks, Red River Lake	Raw	20	18	20	16	16	17	19	18	18	21	22	18
	Treated	12	12	9	9	6	8	6	4	6	13	8	13
Eveleth, St. Mary's Lake	Raw	13	12	12	12	9	9	10	10	9	12	11	14
	Treated	12	13	12	11	12	8	10	8	8	10	9	15
Fairmont, Budd Lake	Raw	16	11	10	11	12	9	12	9	12	11	6	14
	Treated	7	6	6	6	5	8	4	4	3	6	4	7
Hallock, Two Rivers South Fork	Raw	25	28	29	20	22	22	29	20	21	18	17	17
	Treated	10	10	9	7	6	10	10	7	8	11	10	9
International Falls, Rainey River	Raw	11	9	8	10	9	7	6	6	5	8	11	11
	Treated	10	10	8	6	6	7	6	3	4	5	9	9
Minneapolis tap water	Treated	6	5	5	4	4	5	5	4	2	6	6	6
St. Cloud, Mississippi River	Raw	NS	NS	5	NS	9	10	10	7	NS	13	11	20
	Treated	NS	NS	4	NS	4	8	5	2	NS	7	7	9
St. Paul, Vadnais Chain of Lakes	Raw	12	9	9	9	8	9	9	8	8	11	11	12
	Treated	6	7	8	4	5	4	3	3	4	5	6	7

NS, no sample.

Table 2. Average gross alpha radioactivity in Minnesota raw and treated water supplies, July 1970-June 1971

Town and water source	Type of water	Average concentration (pCi/liter)											
		1970						1971					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<5	<4	<3	<2	<3	<3	<1	<2	<2	<3	<3	<3
	Treated	<4	<3	<2	<3	<2	<2	<2	<1	<2	<2	<2	<3
East Grand Forks, Red River Lake	Raw	<3	<2	<2	<2	<2	<3	<2	<3	<3	<2	<5	<2
	Treated	<2	<2	<1	<1	<2	<2	<2	<2	<2	<2	<2	<2
Eveleth, St. Mary's Lake	Raw	<1	<3	<1	<1	<2	<3	<1	<2	<1	<1	<2	<2
	Treated	<2	<2	<1	<1	<2	<2	<1	<2	<1	<1	<2	<1
Fairmont, Budd Lake	Raw	8	<4	<3	<2	<3	<3	<3	<4	<5	<3	<4	<3
	Treated	<3	<2	<1	<2	<2	<2	<2	<2	<2	<2	<2	<3
Hallock, Two Rivers South Fork	Raw	<4	<5	<4	<4	<4	<4	<4	5	<4	<3	2	<1
	Treated	<2	<2	<2	<2	<2	<3	<3	<1	<2	<2	2	<2
International Falls, Rainey River	Raw	<1	<1	<1	<1	<1	1	<1	<1	<1	<2	<1	<1
	Treated	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Minneapolis tap water	Treated	<2	<2	<1	<2	<1	<1	<2	<1	<2	<1	1	2
St. Cloud, Mississippi River	Raw	NS	NS	<2	NS	<4	<4	<1	<1	NS	<2	<2	<3
	Treated	NS	NS	2	NS	<2	<2	<2	<1	NS	<1	<1	<2
St. Paul, Vadnais Chain of Lakes	Raw	<3	<2	<2	<2	<2	<2	<3	<2	<2	<2	<1	<2
	Treated	<3	<2	<1	<1	<1	<1	<1	<1	<2	<1	1	<2

NS, no sample

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	November 1971

Radiostrontium in tap water July-December 1971

Health and Safety Laboratory[1]
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentrations and cesium-137 to strontium-90 ratios in New York City tap water for July through December 1971 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL–257 (July 1, 1972). This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

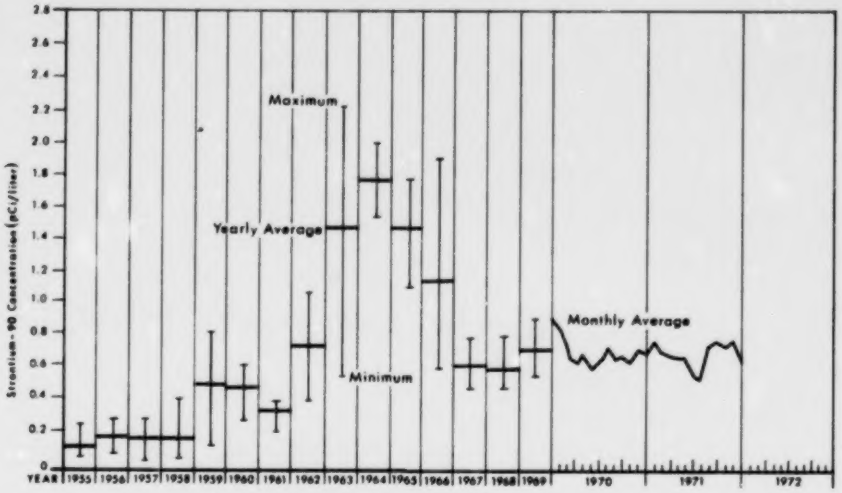

Figure 1. Strontium-90 concentrations in New York City tap water
1955–December 1971

Table 1. Radiostrontium in New York City tap water
July-December 1971

Sampling months	Strontium-90ª	Cesium-137/ strontium-90
July	0.51	0.16
August	.72	.13
September	.74	.12
October	.72	.11
November	.74	.11
December	.61	.09

ª Approximately 100 liters per sample.

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(2) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–June 1971	April 1972

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summariezd periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–December 1970	December 1971
Mexican Air Monitoring Program	January–April 1972	September 1972
Plutonium in Airborne Particulates	October–December 1971	July 1972
Surface Air Sampling Program; 80th Meridian Network, *HASL*	January–December 1969	February 1972

1. Radiation Alert Network
July 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 69 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate sample at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compliation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by field estimate technique, during July 1972.

A high reading in a single precipitation sample of 32 nCi/m^2 was reported at Richmond, Va.

All other field estimates reported were within normal limits for the reporting station.

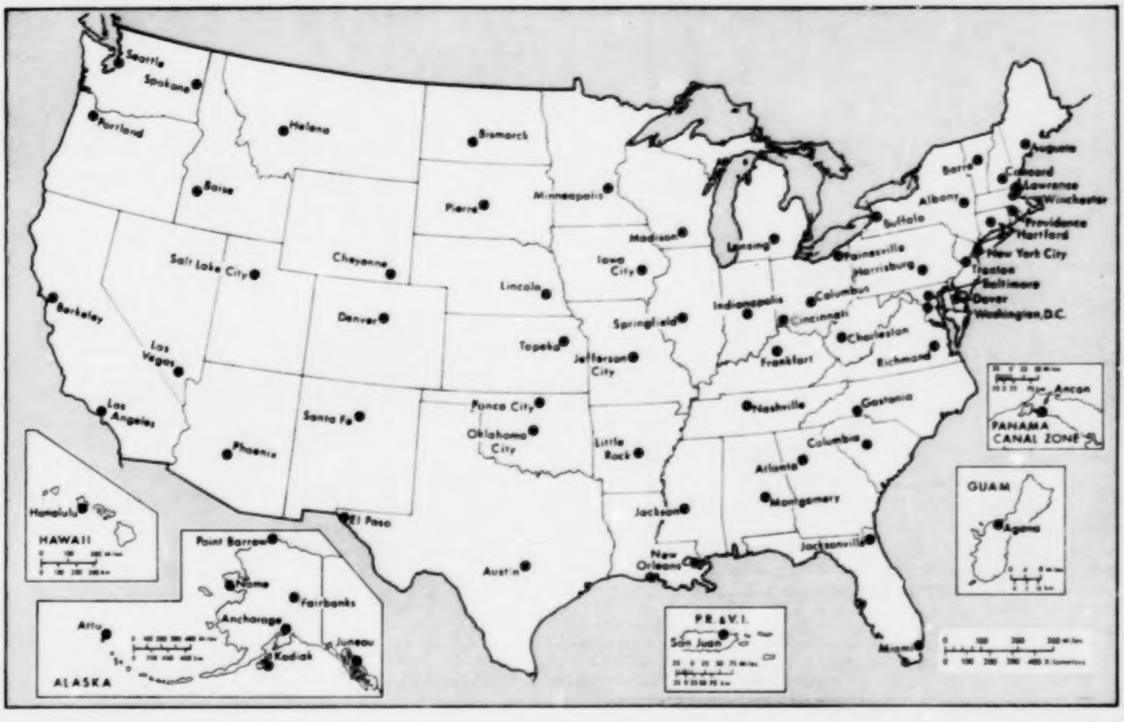
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
Madison
Lansing
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Iowa City
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Indianapolis
Columbus
Cincinnati
Springfield
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Ancon
PANAMA CANAL ZONE
Phoenix
Little Rock
Columbia
Atlanta
GUAM
Agana
Honolulu
HAWAII
Montgomery
Jackson
El Paso
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
Austin
New Orleans
Jacksonville
P.R. & V.I.
San Juan
Miami

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, July 1972

Station location		Gross beta radioactivity (5-hour field estimate) (pCi/m³)				Precipitation				
								Field estimation of deposition		
		Number of samples	Maximum	Minimum	Average[a]	Number of samples	Total depth (mm)	Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	3	0	1	3	163	3	163	18
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	31	1	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	19	6	0	3	0				
Ark:	Little Rock	19	2	0	1	0				
Calif:	Berkeley	20	0	0	0	0				
	Los Angeles	17	2	0	1	0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	20	5	1	2	2	6	(b)		
Conn:	Hartford	20	1	0	0	7	76	7	76	0
Del:	Dover	19	1	0	0	0				
D.C:	Washington	27	1	0	0	0				
Fla:	Jacksonville	20	1	0	0	4	90	4	90	15
	Miami	0				0				
Ga:	Atlanta	12	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	19	0	0	0	0				
Idaho:	Boise	19	2	1	1	1	2	1	2	0
Ill:	Springfield	8	3	1	1	0				
Ind:	Indianapolis	18	2	0	1	0				
Iowa:	Iowa City	16	4	0	1	6	169	6	169	6
Kans:	Topeka	19	3	1	2	7	110	7	110	3
Ky:	Frankfort	2	3	1	2	0				
La:	New Orleans	18	0	0	0	13	165	(b)		
Maine:	Augusta	18	1	0	0	8	79	7	77	0
Md:	Baltimore	19	2	0	1	5	35	5	35	4
Mass:	Lawrence	18	1	0	0	5	91	5	91	0
	Winchester	17	2	0	1	3	39	3	29	0
Mich:	Lansing	19	1	0	1	7	71	7	71	10
Minn:	Minneapolis	13	2	0	1	7	139	7	139	20
Miss:	Jackson	17	2	0	1	4	67	4	67	7
Mo:	Jefferson City	19	4	0	1	5	52	5	52	0
Mont:	Helena	19	3	0	1	3	14	3	14	0
Nebr:	Lincoln	16	7	1	3	2	47	2	47	20
Nev:	Las Vegas	20	2	0	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	2	0	0	7	82	7	82	2
N. Mex:	Santa Fe	16	2	0	1	0				
N.Y:	Albany	13	1	0	1	0				
	Buffalo	19	1	0	1	0				
	New York City	0				0				
N.C:	Gastonia	5	6	1	2	2	37	(b)		
N. Dak:	Bismarck	20	7	0	2	6	54	6	54	9
Ohio:	Cincinnati	0				0				
	Columbus	3	1	1	1	0				
	Painesville	20	2	0	1	5	67	5	67	15
Okla:	Oklahoma City	13	4	1	1	0				
	Ponca City	20	3	0	1	6	99	5	96	0
Oreg:	Portland	14	0	0	0	1	5	1	5	0
Pa:	Harrisburg	15	2	0	1	1	15	1	15	2
P.R:	San Juan	0				0				
R.I:	Providence	19	1	0	0	0				
S.C:	Columbia	15	2	0	1	5	96	4	86	0
S. Dak:	Pierre	20	5	1	2	0				
Tenn:	Nashville	19	2	0	1	5	148	5	148	10
Tex:	Austin	20	4	0	2	4	59	(b)		
	El Paso	18	3	0	1	0				
Utah:	Salt Lake City	31	2	0	1	1	1	1	1	0
Vt:	Barre	17	4	0	2	8	72	8	72	5
Va:	Richmond	17	1	0	0	2	76	2	76	41
Wash:	Seattle	8	0	0	0	2	16	(b)		
	Spokane	20	2	0	1	0				
W. Va:	Charleston	17	3	0	1	7	81	7	81	26
Wisc:	Madison	20	2	0	1	8	92	8	92	8
Wyo:	Cheyenne	15	4	0	3	0				
Network summary		1,008	7	0	1	162	83	5	73	10

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] July 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for July 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, July 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.1	0.0	0.1	17	1.2
Coral Harbour	5	.0	.0	.0	66	2.0
Edmonton	5	.1	.1	.1	20	1.1
Ft. Churchill	5	.2	.1	.1	3	.3
Fredericton	5	.2	.1	.1	33	2.3
Goose Bay	5	.1	.0	.1	21	1.2
Halifax	7	.2	.1	.1	37	2.2
Inuvik	5	.0	.0	.0	6	.2
Montreal	5	.1	.0	.1	14	2.1
Moosonee	5	.1	.0	.1	14	1.3
Ottawa	5	.1	.1	.1	8	1.5
Quebec	5	.1	.1	.1	6	.8
Regina	4	.1	.1	.1	24	1.5
Resolute	5	.0	.0	.1	173	1.6
St. John's, Nfld	5	.1	.0	.1	82	1.6
Saskatoon	5	.1	.1	.1	25	1.6
Sault Ste. Marie	1	.1	.1	.1	6	.4
Thunder Bay	5	.1	.1	.1	13	1.5
Toronto	5	.1	.0	.1	16	1.0
Vancouver	5	.1	.0	.1	20	1.6
Whitehorse	5	.2	.0	.1	32	2.1
Windsor	5	.2	.1	.1	30	1.2
Winnipeg	5	.1	.1	.1	18	1.1
Yellowknife	1	.1	.1	.1	63	2.3
Network summary	113	0.2	0.0	0.1	31	1.4

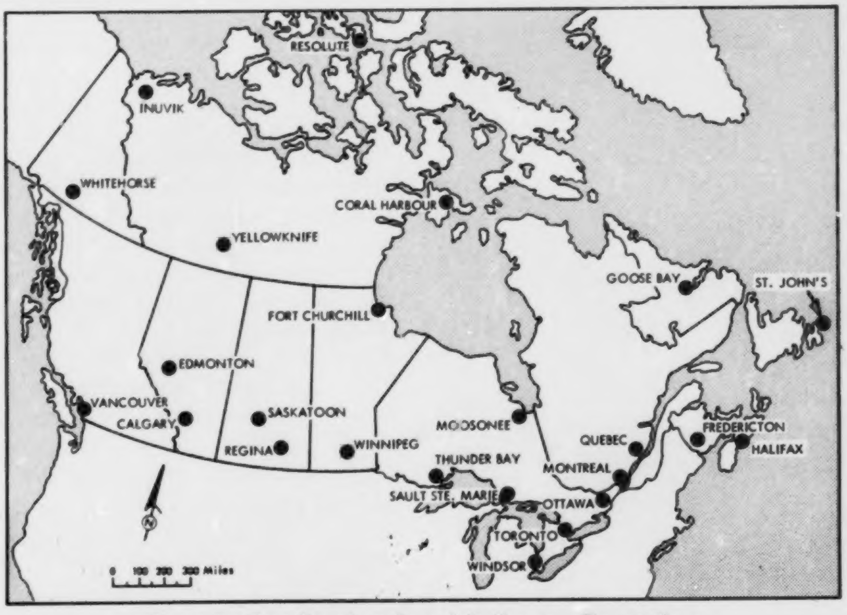
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
FREDERICTON
QUEBEC
HALIFAX
REGINA
WINNIPEG
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program
July 1972

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The July 1972 air monitoring results from the participating countries are given in table 3.

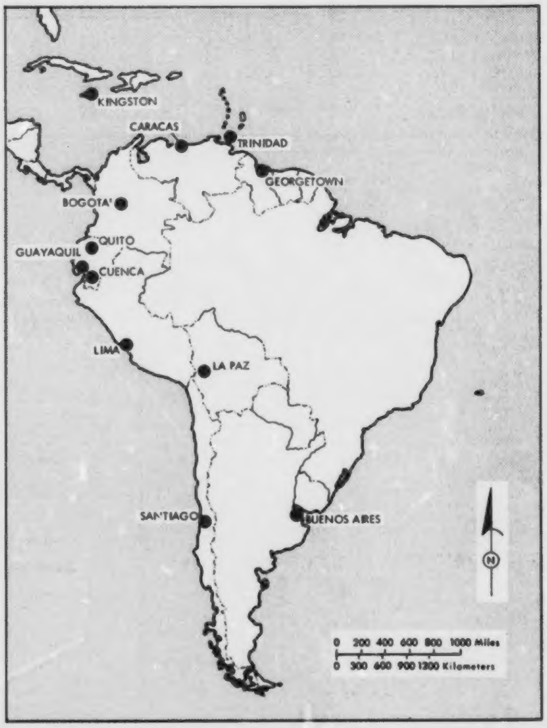

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, July 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	3	0.04	0.03	0.03
Chile:	Santiago	29	[b]17.85	.02	1.39
Colombia:	Bogota	20	.02	.00	.01
Ecuador:	Cuenca	5	.02	.00	.01
	Guayaquil	14	.44	.02	.13
	Quito	21	.02	.00	.00
Guyana:	Georgetown	2	.03	.01	.02
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	5	.11	.01	.05
West Indies:	Trinidad	0			
Pan American summary		99	17.85	0.00	0.43

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

[b] Activity identified as barium-140, lanthanum-140, iodine-131, ruthenium-103, zirconium-niobium-95.

4. California Air Sampling Program
July 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for the month of July 1972. The monthly sample results are presented quarterly.

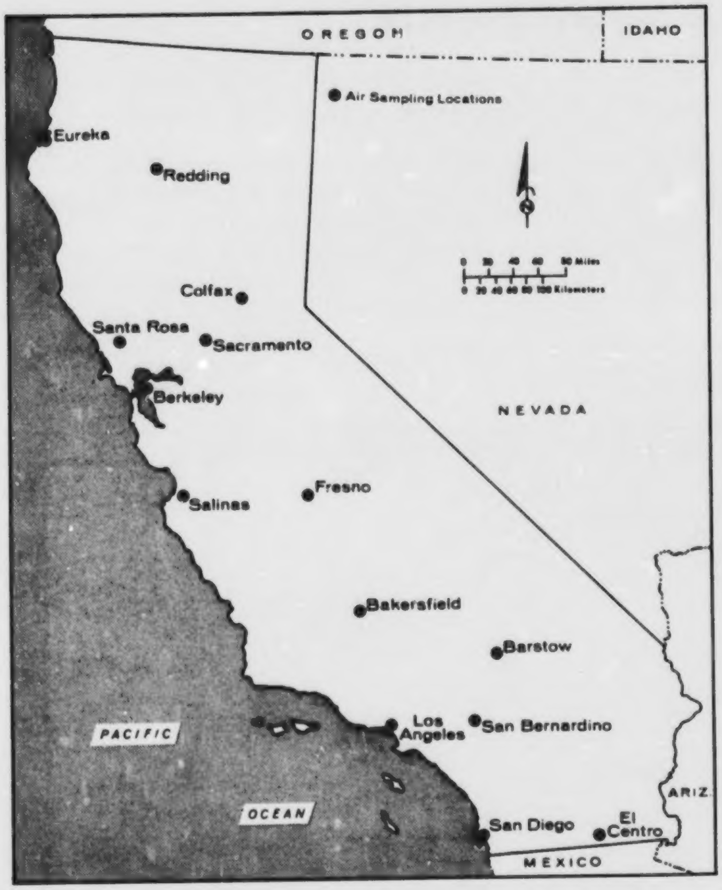
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
San Diego
El Centro
ARIZ.
MEXICO
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers

Figure 4. California air sampling program stations

Table 4. Gross beta radioactivity in Califronia air,[a] July 1972

Station location	Number of samples	Gross beta radioactivity[b] (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	31	0.81	0.12	0.35
Barstow	31	.70	.14	.33
Berkeley	31	.32	.01	.13
Colfax	31	.60	.10	.29
El Centro	31	1.00	.06	.24
Eureka	31	.18	.03	.07
Fresno	31	.75	.14	.31
Los Angeles	31	.39	.02	.16
Redding	31	.54	.12	.29
Sacramento	31	.56	.08	.21
Salinas	31	.58	.06	.25
San Bernardino	31	.89	.12	.30
San Diego	31	.40	.08	.18
Santa Rosa	30	.47	.00	.14
Summary	433	1.00	0.00	0.23

[a] Daily alpha levels are available for Berkeley and Los Angeles. Monthly averages are 0.1 and 0.1 pCi/m³, respectively.

[b] Samples taken at Orange, Calif., July 7 and 21, 1972 resulted in a gross beta activity of 0.30 and 0.10, respectively which resulted in a summary of 0.20.

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(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare. Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

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Air Surveillance Network, July 1972

National Environmental Research Center-Las Vegas[1], Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station which lies within the NTS, and by the AEC at any other designated testing sites.[2]

The stations are operated by State health

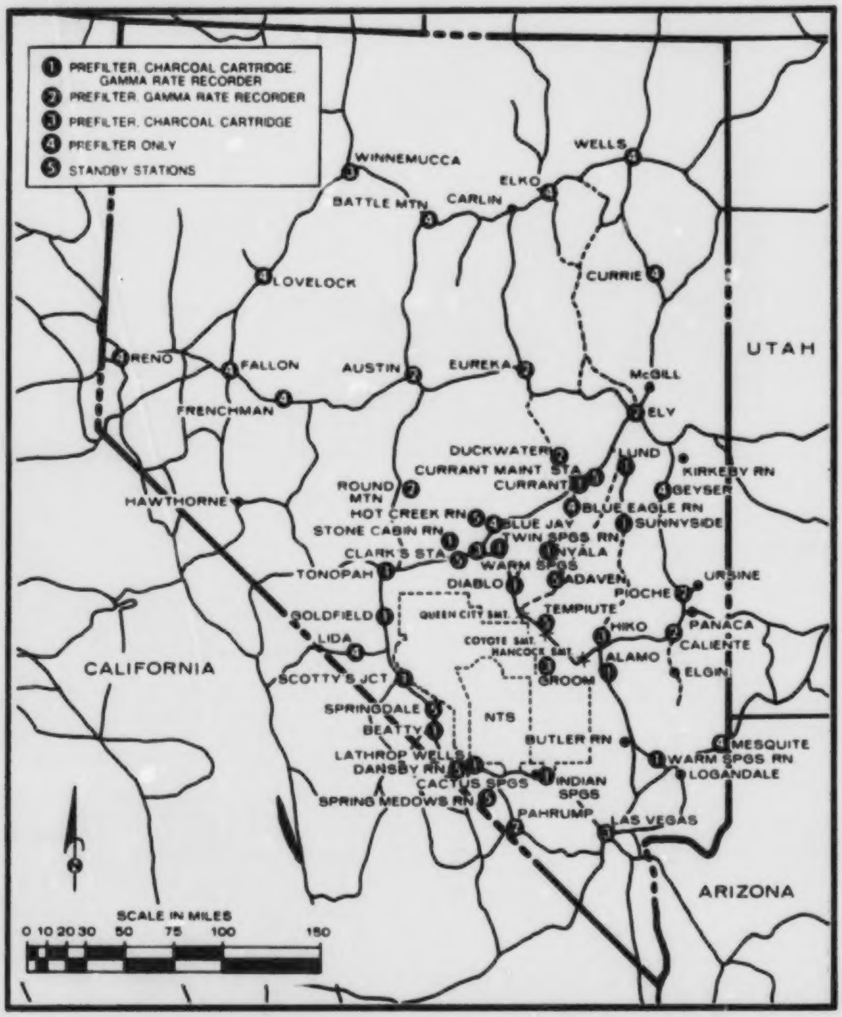
❶ PREFILTER, CHARCOAL CARTRIDGE, GAMMA RATE RECORDER
❷ PREFILTER, GAMMA RATE RECORDER
❸ PREFILTER, CHARCOAL CARTRIDGE
❹ PREFILTER ONLY
❺ STANDBY STATIONS
WINNEMUCCA
WELLS
ELKO
BATTLE MTN
CARLIN
LOVELOCK
CURRIE
UTAH
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT STA
KIRKEBY RN
ROUND MTN
CURRANT
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE EAGLE RN
STONE CABIN RN
BLUE JAY
SUNNYSIDE
TWIN SPGS RN
CLARK'S STA
NYALA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
URSINE
PIOCHE
QUEEN CITY SMT.
TEMPIUTE
GOLDFIELD
HIKO
PANACA
COYOTE SMT.
HANCOCK SMT.
CALIENTE
LIDA
CALIFORNIA
ALAMO
GROOM
ELGIN
SCOTTY'S JCT
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEDOWS RN
PAHRUMP
LAS VEGAS
ARIZONA
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Table 1. Summary of gross beta radioactivity concentrations in air, July 1972

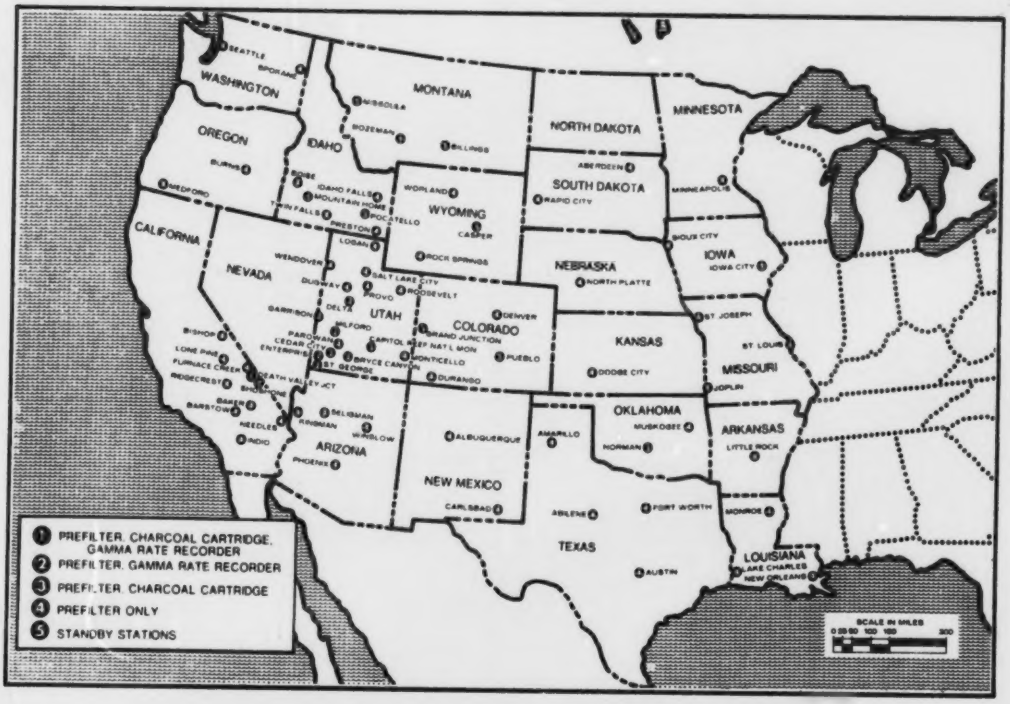
Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Ariz:	Kingman	31	0.4	<0.1	0.1
	Phoenix	31	.2	<.1	.1
	Seligman	31	.5	<.1	.2
	Winslow	31	.5	<.1	.1
Ark:	Little Rock	20	.4	<.1	.2
Calif:	Baker	29	.4	.1	.2
	Barstow	31	.7	<.1	.2
	Bishop	31	.4	<.1	.2
	Death Valley Junction	31	.6	<.1	.3
	Furnace Creek	29	.4	<.1	.2
	Indio	30	.3	<.1	.2
	Lone Pine	30	.5	<.1	.2
	Needles	24	.3	.1	.2
	Ridgecrest	31	.5	<.1	.2
	Shoshone	30	.3	.1	.2
Colo:	Denver	20	.4	.1	.2
	Durango	31	.4	.1	.2
Idaho:	Boise	31	.7	<.1	.3
	Idaho Falls	20	.6	.1	.3
	Preston	31	.6	.1	.3
	Twin Falls	31	.6	.1	.3
Iowa:	Iowa City	19	.3	<.1	.2
	Sioux City	17	.5	<.1	.2
Kans:	Dodge City	31	.4	<.1	.2
La:	Lake Charles	19	.6	.1	.1
	Monroe	17	.8	<.1	.2
	New Orleans	19	.7	<.1	.2
Minn:	Minneapolis	17	.4	.1	.2
Mo:	Joplin	31	.6	.1	.2
	St. Joseph	31	.5	<.1	.2
	St. Louis	30	.4	<.1	.2
Nebr:	North Platte	25	.3	<.1	.2
Nev:	Alamo	31	.4	<.1	.2
	Austin	20	.4	.1	.3
	Battle Mountain	31	.5	.1	.3
	Beatty	31	.4	.1	.2
	Blue Eagle Ranch (Currant)	29	.6	<.1	.3
	Blue Jay	31	.7	<.1	.2
	Caliente	30	.5	<.1	.2
	Currant Ranch	31	.5	<.1	.2
	Currie	31	.7	<.1	.3
	Diablo	32	.4	<.1	.2
	Duckwater	25	.5	<.1	.2
	Elko	31	.6	<.1	.3
	Ely	29	.5	.1	.2
	Eureka	31	.5	<.1	.2
	Fallini's Twin Springs Ranch	32	.5	<.1	.3
	Fallon	30	.5	<.1	.3
	Frenchman Station	31	.4	<.1	.2
	Geyser Maintenance Station	31	.6	<.1	.2
	Goldfield	31	.5	<.1	.2
	Groom Lake	31	.8	<.1	.2
	Hiko	30	.9	<.1	.3
	Indian Springs	31	.5	<.1	.2
Nev:	Las Vegas	20	.3	0.1	.2
	Lathrop Wells	28	.7	<.1	.2
	Lida	31	.4	<.1	.2
	Lovelock	31	.7	.1	.3
	Lund	31	.4	<.1	.2
	Mesquite	31	.4	<.1	.2
	Nyala	31	.5	<.1	.2
	Pahrump	11	.2	.1	.1
	Pioche	29	.4	<.1	.2
	Reno	32	.5	.1	.3
	Round Mountain	30	.5	<.1	.2
	Scotty's Junction	30	.6	<.1	.2
	Stone Cabin Ranch	30	.5	<.1	.2
	Sunnyside	25	.5	<.1	.2
	Tonopah	31	.5	<.1	.2
	Tonopah Test Range	18	.4	.1	.2
	Warm Springs	31	.4	<.1	.2
	Warm Springs Ranch	27	.4	<.1	.2
	Wells	31	.7	<.1	.3
	Winnemucca	31	.6	<.1	.3
N. Mex:	Albuquerque	22	.5	<.1	.2
	Carlsbad	30	.2	<.1	.1
Okla:	Muskogee	30	.4	.1	.2
Oreg:	Burns	31	.5	<.1	.3
	Medford	26	.4	.1	.2
S. Dak:	Aberdeen	31	.7	<.1	.2
	Rapid City	30	.4	<.1	.2
Tex:	Abilene	29	.3	<.1	.1
	Amarillo	30	.3	<.1	.1
	Austin	19	.2	.1	.1
	Fort Worth	30	.4	<.1	.2

See footnotes at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air July 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Utah:	Bryce Canyon	28	.4	<.1	.2
	Cedar City	30	.5	.1	.2
	Delta	31	.7	<.1	.3
	Dugway	31	.7	<.1	.3
	Enterprise	31	.3	<.1	.2
	Garrison	31	.6	<.1	.3
	Logan	31	.6	<.1	.3
	Milford	31	.4	<.1	.2
	Monticello	12	.4	<.1	.3
	Parowan	28	.6	<.1	.2
	Provo	30	1.2	<.1	.3
	Roosevelt	30	.5	.1	.2
	Salt Lake City	31	.5	<.1	.2
	St. George	30	.4	<.1	.2
	Wendover	30	.7	<.1	.3
Wash:	Seattle	21	.3	.1	.1
	Spokane	20	.4	<.1	.2
Wyo:	Rock Springs	21	.4	<.1	.2
	Worland	31	.7	<.1	.2

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.


WASHINGTON
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OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNESOTA
MINNEAPOLIS
CALIFORNIA
NEVADA
UTAH
LOGAN
WENDOVER
DUGWAY
SALT LAKE CITY
PROVO
ROOSEVELT
GARRISON
DELTA
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST GEORGE
BRYCE CANYON
CAPITOL REEF NAT'L MON
GRAND JUNCTION
MONTICELLO
COLORADO
DENVER
PUEBLO
DURANGO
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
KANSAS
DODGE CITY
MISSOURI
ST JOSEPH
ST LOUIS
JOPLIN
BISHOP
LONE PINE
FURNACE CREEK
DEATH VALLEY JCT
RIDGECREST
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
ARIZONA
SELIGMAN
KINGMAN
WINSLOW
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
AMARILLO
OKLAHOMA
MUSKOGEE
NORMAN
ARKANSAS
LITTLE ROCK
TEXAS
ABILENE
FORT WORTH
AUSTIN
LOUISIANA
MONROE
LAKE CHARLES
NEW ORLEANS
SCALE IN MILES
0 25 50 100 150 300
① PREFILTER, CHARCOAL CARTRIDGE, GAMMA RATE RECORDER
② PREFILTER, GAMMA RATE RECORDER
③ PREFILTER, CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

department personnel and by private individuals on a contract basis. Daily 24-hour samples are collected at each station. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates for each of the network stations. The minimum reported concentration for gross beta is 0.1 pCi/m^3; however, gross beta concentrations above the minimum detectable concentration of 0.06 pCi/m^3 are used in determining averages. Individual concentrations which are below the minimum detectable concentration are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reported level are reported as <0.1 pCi/m^3. The highest gross beta concentration within the network on a single filter during July was 1.2 pCi/m^3 at Provo, Utah.

From gamma spectrometry results, zirconium-95 was identified on samples collected in Minnesota and Nevada. The highest concentration was 0.2 pCi/m^3 at Elko, Nev. This radionuclide is attributed to foreign atmospheric testing.

Copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for S1C Prototype Reactor Facility and Shippingport Atomic Power Station.

1. S1C Prototype Reactor Facility[2]
January–December 1970

Combustion Engineering, Inc.
Windsor, Conn.

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. (figure 1). The prototype contains a pressurized water reactor power plant which is primarily used to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are rou-

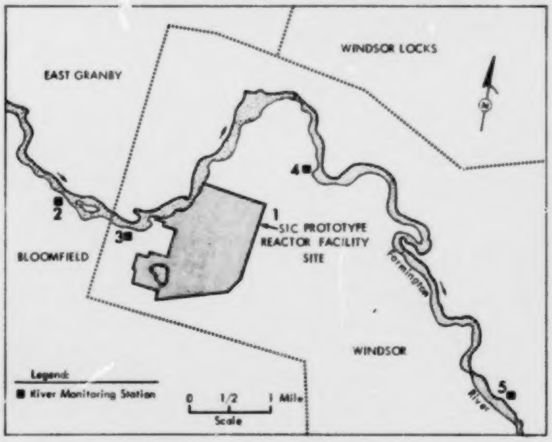

Figure 1. Environmental monitoring locations, S1C Prototype site

tinely monitored to assure that waste disposal operations comply with AEC regulations.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report for 1970".

Liquid radioactive waste

Drainage from all systems which are known to contain radioactive liquids were collected, processed and sampled prior to discharge to the environment to assure that discharge concentrations were within the required limits. In addition, waste effluent is sampled as it is discharged to the environment and results indicated that concentrations were within the required limits.

The S1C Prototype discharged a total of 1.99 megaliters of radioactive liquid waste containing 457.8 microcuries of radioactivity during 1970 for an annual average discharge concentration of 230 pCi/liter.

Water monitoring

Water and sediment samples from the Farmington River are taken quarterly and analyzed. These samples are used to determine if buildup (reconcentration of radioactivity) is occurring.

Results of sampling of the Farmington River during 1970 are shown in table 1. During 1970, gross gamma radioactivity of water samples from the outlet of the S1C discharge brook was well below the 30 nCi/liter maximum permissible concentration specified by the Federal Regulations for cobalt-60, the most limiting radionuclide in S1C wastes.

Table 1. Gross gamma radioactivity in Farmington River 1970

Period (1970)	Number of samples	Gross gamma concentration (pCi/liter)	Range of gross gamma concentration (pCi/liter)
January-March	(a)		
April-June	3	120	80–180
July-September	3	130	89–210
October-December	3	34	80– 93

[a] Sample not taken because of ice on river.

Results of the analysis of sediment samples taken at the outflow of the S1C Prototype discharge brook are contained in table 2.

Table 2. Farmington River sediment sample results, 1970

Period (1970)	Number of samples	Gross gamma concentration (pCi/liter)	Range of gross gamma concentration (pCi/liter)
January-March	(a)		
April-June	3	2.4	1.5–2.9
July-September	3	2.9	1.9–4.6
October-December	3	2.5	2.0–3.4

[a] Sample not taken because of ice on river.

Airborne radioactivity

All areas onsite where gaseous and/or particulate airborne radioactivity could be present are directed through ducts to monitored stacks. The stacks are monitored for airborne levels on a continuous basis.

The airborne particulate radioactivity samples taken during discharge are monitored again after allowing short-lived radioactivity from natural radon decay products to decay. During 1970, the total particulate radioactivity released from the S1C site was less than 0.0063 curies.

Radiation evaluation

Film badges were posted on the site's exclusion area perimeter for the detection of beta-gamma radiation. The badges were processed monthly and the exposure results were generally less than 10 millirem. The normal background for the surrounding area not influenced by S1C Prototype operation is also 10 millirem per month.

Conclusions

Results of the analyses and of the continuous monitoring throughout 1970 have indicated that S1C Prototype operations have met all of the Federal Regulations pertaining to AEC standards. Environmental analyses indicate that no significant quantities of radioactivity have accumulated above the preoperational environmental results. It is, therefore, concluded that the facility operations have not adversely affected the surrounding environment.

Recent coverage in *Radiation Data and Reports.*

Period	Issue
January–December 1969	December 1970

2. Shippingport Atomic Power Station[3] January–December 1970

Duquesne Light Company
Shippingport, Pa.

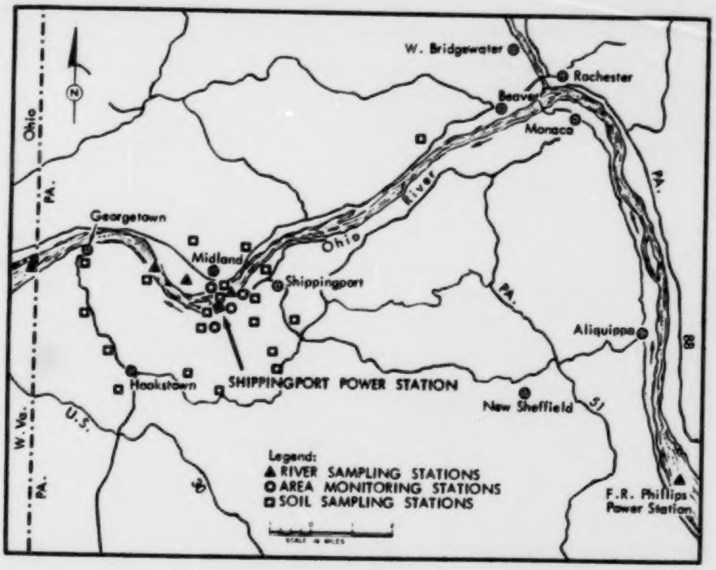
The Shippingport Atomic Power Station is located on the south bank of the Ohio River in a site consisting of over 400 acres. The site is about 25 miles west of Pittsburgh and about 11 miles below the confluence of the Beaver and Ohio Rivers (figure 2). The station is designed to produce electric energy by a conventional central station type turbine-generator unit. The pressurized water reactor consists of a closed system in which water is circulated by pumps over an array of nuclear fuel elements, or core, contained in a reactor vessel, to heat exchangers where stream is formed in a separate isolated system.

Radioactive waste handled under the environmental program includes liquid and gaseous effluents released into the Ohio River and atmosphere, respectively. The levels of radioactivity released were below Shippingport discharge limits. These limits are based upon radiation standards set forth by AEC's division of Operational Safety in directives published in the AEC Manual,[1] and a waste discharge permit from the Pennsylvania Sanitary Water Board.

Liquid radioactive waste

The liquid radioactive wastes disposed of at Shippingport are primarily from the reactor coolant system. The radioactive waste produced by the plant is reduced in concentration in such a manner that the concentration of these wastes in water measured at the condenser water stream, before discharge to the Ohio River, meets the limits as delineated above. In order to assure that the liquid discharged from the plant will meet specified tolerances, all radioactive waste is collected, processed, and sampled prior to discharge to the environment.

During 1970, a total of 71 mCi gross beta-gamma radioactivity in the liquid waste (exclusive of tritium) and 1.72 Ci of tritium in liquid waste were released into the environment. The average daily discharge of tritium during this period was 4.7 mCi. All reported concentrations released to the environment were well below those specified by State and Federal regulations.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SHIPPINGPORT POWER STATION
Hookstown
New Sheffield
51
U.S.
30
W. Va.
PA.
Legend:
▲ RIVER SAMPLING STATIONS
○ AREA MONITORING STATIONS
□ SOIL SAMPLING STATIONS
SCALE IN MILES
F.R. Phillips Power Station

Figure 2. Shippingport power station sampling locations

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[3] Summarized from Environmental Radioactivity at the Shippingport Atomic Power Station for the Calendar Year 1970."

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Table 3. Gross radioactivity in the Ohio River, Shippingport Atomic Power Station, January-December 1970

Type of radioactive material	Average concentration (pCi/liter)							
	Influent samples				Effluent samples			
	Jan-Mar	Apr-June	July-Sept	Oct-Dec	Jan-Mar	Apr-June	July-Sept	Oct-Dec
Alpha:								
Total solids	1.08	1.92	1.98	5.36	1.09	1.06	1.14	2.43
Beta:								
Total solids	1.12	21.8	16.7	17.4	8.8	15.3	10.9	10.1
Potassium-40	3.5	5.4	6.4	4.8	3.6	5.3	6.4	4.8

Ohio River water analysis

During 1970, weekly composite samples were obtained from two continuous automatic samplers in the station circulating water line upstream and downstream of the radioactive water effluent. Both suspended and dissolved materials in the composite samples were analyzed for gross alpha and beta-gamma radioactivity. Each composite is also analyzed for potassium-40 content. No significant difference was observed among the average alpha, beta-gamma, and potassium-40 radioactivity for the influent and effluent samples. The results of these analyses are presented in table 3.

Ohio River sediment analysis

Once during each calendar quarter, sediment samples of the Ohio River were collected upstream and downstream of the circulating water outfall with a Birge-Ekman dredge. These samples were quantitiated assuming all detected radioactivity to be cobalt-60, which is the major constituent of radioactive contamination at the station. The results of the sediment samples are presented in table 4. These data indicate that there was no increase of radioactivity in the river sediment as a result of the station's discharges.

Table 4. Total radioactivity in the Ohio River sediment samples, Shippingport, January-December 1970

1970	Number of samples	Gross radioactivity (pCi/g)	
		Upstream	Downstream
January-March	2	16.1	18.5
April-June	2	10.4	18.1
July-September	2	16.0	12.0
October-December	2	9.3	7.6

Gaseous radioactive waste

Gaseous discharges to the atmosphere, identified as xenon-133, are controlled and released at concentrations less than the AEC standard of 300 nCi/m^3. During the year 1970, a total of 19 microcuries of xenon-133 were released from the plant site at less than the specified concentration.

Film badge monitoring

Twelve film badges for detecting beta-gamma radioactivity were posted continuously at the site perimeter in an attempt to determine the external radiation exposure in the immediate area. In order to accomplish this, a control film badge location was established at a point 10 miles from the station boundary.

The density of the offsite monitoring film was not measurably different from the control film. This indicates that the film exposure at all locations averaged <0.03 mrem/h for each month of 1970 which is considered normal background radiation for this area. These results show that radiation exposure to the general public outside the station was not above that received from natural background radiation levels.

Fallout

Precipitation and fallout are collected in a high-walled pot at one location on the site and analyzed monthly for gross alpha and beta radioactivity. A summary of the quarterly average fallout results for 1970 is presented in table 5.

Table 5. Radioactivity in fallout, Shippingport January-December 1970

1970	Deposition rate (nCi/m^2-month)	
	Alpha radioactivity	Beta radioactivity
January-March	0.32	8.64
April-June	.51	36.90
July-September	.85	12.96
October-December	.31	8.65
12-month average	0.49	16.83

Conclusion

From the data presented above, it may be concluded that during 1970 the radioactive effluent released from the Shippingport Station site did not cause any significant increase in background radiation levels. In this regard, the station procedures relative to controlling radioactive discharges to the environment are considered to be effective in protecting the health and safety of the general public.

Recent coverage in *Radiological Health Data and Reports.*

Period	Issue
January–December 1969	November 1970

Reported Nuclear Detonations, October 1972

(Includes seismic signals presumably from foreign nuclear detonations)

There were no United States nuclear detonations reported by the U.S. Atomic Energy Commission in October 1972.

The U.S. Atomic Energy Commission announced that the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion, on October 3, 1972. The signals originated south of Volgograd and were equivalent to those of an underground explosion of 200 kilotons to 1 megaton.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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☆U.S. GOVERNMENT PRINTING OFFICE: 1972 — 514-842/11

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL RADIOACTIVITY IN ILLINOIS, 1970. Moshe J. Shmuklarsky. Radiation Data and Reports, Vol. 13, November 1972, pp. 589–618.

The contribution of radioactivity to the Illinois environment during 1970 resulting from the operation of nuclear power plants and from other major natural and manmade sources is presented. The environmental surveillance programs of the Dresden, Quad-Cities and Zion nuclear power stations are described. Dresden Unit 1 radioactive gaseous and liquid releases for the past 11 years, and Dresden Unit 2 discharges for 1970 are summarized. On the basis of data gathered during 1970, it is concluded that the effect of nuclear power plant operations on the radioactivity level of most environmental media was hardly distinguishable from the natural and fallout radioactivity. The only measured environmental radiation effect of nuclear power generation within the State was an apparent increase of a few millirem per year in the external background exposure in the vicinity of Dresden-1.

KEYWORDS: Illinois, environment nuclear power, radioactivity, reactors, Dresden, Quad-Cities, Zion, x-ray, cosmic rays, terrestrial.

RADIATION DATA AND REPORTS

Volume 13, Number 12, December 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

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Reports

Use of Fallout Cesium-137 as a Tracer to Define the Recent Deltaic Facies of a River[1]

Phillip Plato,[2] and Gary C. Goldman[3]

Using fallout cesium-137 as a tracer, the size and location of the deltaic facies in Lake Michigan of the St. Joseph River are described. Approximately 185 sediment samples were collected and analyzed for cesium-137 aboard ship during five working days. Contour lines are shown that represent the measured concentrations of cesium-137 in the deltaic facies produced by the St. Joseph River.

When a river discharges its water into a relatively quiescent body of water such as a lake, a deltaic facies may be formed where suspended matter from the river accumulates on the lake sediments near the mouth of the river. The location and size of the deltaic facies are of concern to investigators interested in the movement of manmade waste products through the aquatic environment. Zinc and chromium from plating plants, mercury from chlorine production plants, pesticides from agricultural lands, and many other waste products can enter a river. These pollutants may build up to relatively high concentrations in the deltaic facies produced by a river.

The study of the accumulation of any pollutant in sediment generally involves the collection of large numbers of grab samples of bottom sediment over a predetermined sampling grid. These samples are usually transported to a land-based laboratory where the pollutant to be studied is extracted and measured by an appropriate analytical technique. Since the cost of extraction and analysis is high, only a limited number of samples can usually be processed. Thus, an area of particular interest may be missed altogether. Furthermore, a long lag time usually exists between the time a sample is collected and the time the analytical results are available for study. If several samples from a particular area are found to contain high concentrations of the pollutant, additional sampling might be required to complete the investigation.

This paper describes the procedures and instruments used to determine the size and location of the deltaic facies in Lake Michigan produced by the St. Joseph River (figure 1), using fallout cesium-137 as a tracer. The collection of the sediment samples discussed in this paper and the measurement of these samples for cesium-137 were done aboard the University of Michigan's Research Vessel MYSIS during the summer of 1972. The procedure enabled the investigators to cover a large area of lake bottom in a relatively short period of time with little or no lag time between the collection and analysis of a sample.

Cesium-137 as a tracer

Cesium-137 is a fission product that has entered the environment for over 20 years as a result of atmospheric tests of nuclear weapons. Estimates from a previous study (*1*) of radioactivity in Lake Michigan indicate approximately 15,000 curies of fallout cesium-137

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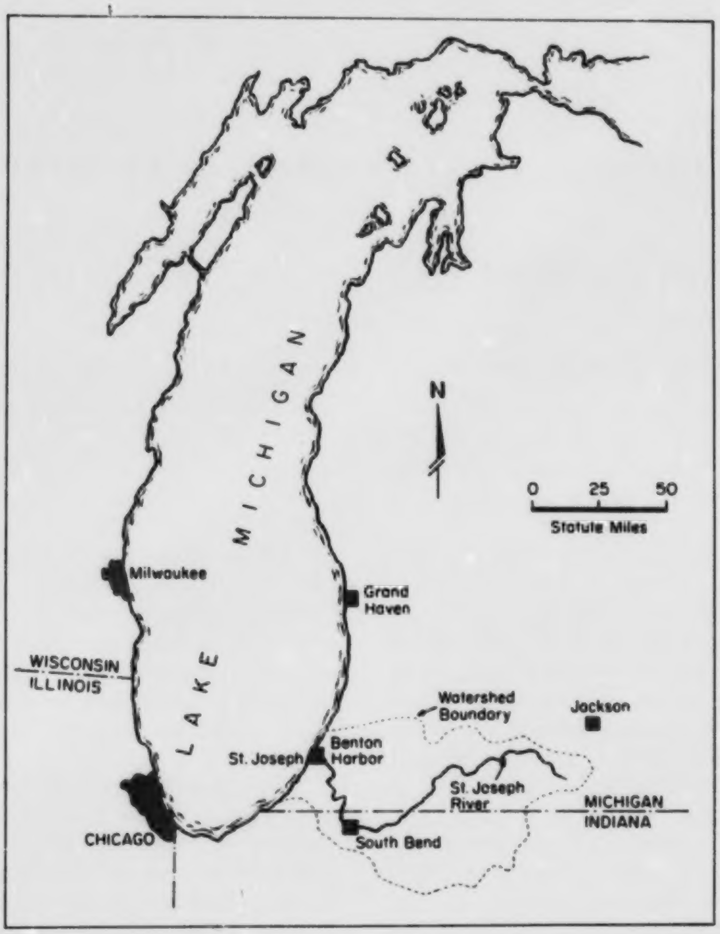
[1] This work was sponsored by a research grant from the American Electric Power Service Corporation.

[2] Assistant professor of Radiological Health, Department of Environmental and Industrial Health, The University of Michigan, Ann Arbor, Mich.

[3] Graduate student, Department of Meteorology and Oceanography, University of Michigan.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Milwaukee
Grand Haven
WISCONSIN
ILLINOIS
Watershed Boundary
Jackson
Benton Harbor
St. Joseph
St. Joseph River
MICHIGAN
INDIANA
CHICAGO
South Bend

Figure 1. Relative locations of the St. Joseph River and its watershed

entered the Lake Michigan watershed between 1950 and 1970. The watershed of the St. Joseph River is approximately 7 percent (by area) of the entire Lake Michigan watershed (*2*). Thus, about 1,000 curies of fallout cesium-137 have entered the St. Joseph River watershed during the past two decades.

Since the element cesium exists primarily in the ionic form, it is reasonable to expect that the isotope cesium-137 remains in the ionic form unless it becomes attached to suspended matter. Kantsky (*3*) found that approximately 10 percent of the cesium-137 in samples of river water was associated with suspended solids while 90 percent remained in the ionic form. Thus, perhaps as much as 100 curies of cesium-137 have been discharged by the St. Joseph River into Lake Michigan attached to suspended solids. Most of these suspended solids subsequently settled to the bottom of the lake. An examination of bottom sediments near the mouth of the St. Joseph River for high accumulations of fallout cesium-137 should indicate areas where the sedimentation rate is the highest.

Several properties make cesium-137 an attractive radionuclide to use as a tracer in the environment. It is among the most abundant fission products produced in the detonation of a nuclear weapon. It has a relatively long half-life of 30 years. It decays by the emission of a gamma ray of high abundance and high energy (85 percent of the decays of cesium-137 result in a gamma ray with an energy of 0.66 MeV). The high abundance and energy of the gamma ray permit a sample of sediment to be measured quantitatively for cesium-137 without extracting the cesium-137 from the sample.

Procedure

Two samples of sediment were collected with a small dredge at each sampling station. The dredge collected a block of sediment with a surface of approximately 23 cm by 23 cm to a depth of about 8 cm. The top 3 cm were removed as carefully as possible from each block of sediment and placed in a plastic bag. The two bags of sediment from each sampling station were placed in an annular configuration around a 7.5 cm diameter by 7.5 cm thick sodium iodide detector to give a reproducible counting geometry. The sodium iodide detector was coupled to a 200-channel pulse height analyzer.

The two bags of sediment collected at each sampling station were counted as one sample for 200 seconds. The pulse height spectrum that was produced by each sample was displayed on an oscilloscope, and the height of the cesium-137 photopeak above background was recorded as a measure of the relative concentration of cesium-137 in the sample.

Results and discussion

Figure 2 shows the locations of the sampling stations and contour lines that represent the measured concentrations of cesium-137 in the sediments of Lake Michigan near the mouth of the St. Joseph River. Approximately 185 samples were collected and analyzed for cesium-137 during five working days aboard ship.

Little or no accumulation of cesium-137 appears to occur within about 8 km of shore. The effect of wave action and turbulence on the bottom is greatest within this area and is probably the main reason why suspended matter from the river does not accumulate near shore.

The predominant water movement near the mouth of the St. Joseph River is toward the north (*4*). Thus, cesium-137 carried into the lake on suspended matter from the river is expected to be distributed over a larger area of the lake bottom north of the river mouth than south. Data shown in figure 2 tend to support this prediction.

The topography of the lake bottom in the area shown in figure 2 bears little resemblance to the measured accumulation patterns of fallout cesium-137. The lake gradually becomes deeper (almost linearly) as the distance from shore increases. Depths of 100 m are encountered beyond 35 km from shore.

The sediment samples collected are currently being analyzed for cesium-137 in the laboratory in the conventional manner (i.e., oven-dried, weighed, and counted) to determine if the field method of analysis is adequate to define areas of relatively high and low concentrations of cesium-137 in sediment. Trace-element measurements will be performed on several samples found to contain very high and very low concentrations of fallout cesium-137 to determine if a correlation exists between relative concentrations of cesium-137 and other manmade pollutants.

A study is in progress (*5*) designed to compare the fallout cesium-137 discharged by the St. Joseph River with the radioactive wastes that will be discharged by two nuclear power plants located on Lake Michigan within 24 km of the river. It is hoped that the accumulation patterns produced by the river (figure 2) can be used to predict the accumulation patterns that will be produced by the nuclear power plants during the next few decades.

Summary

Fifty sediment sampling stations were used

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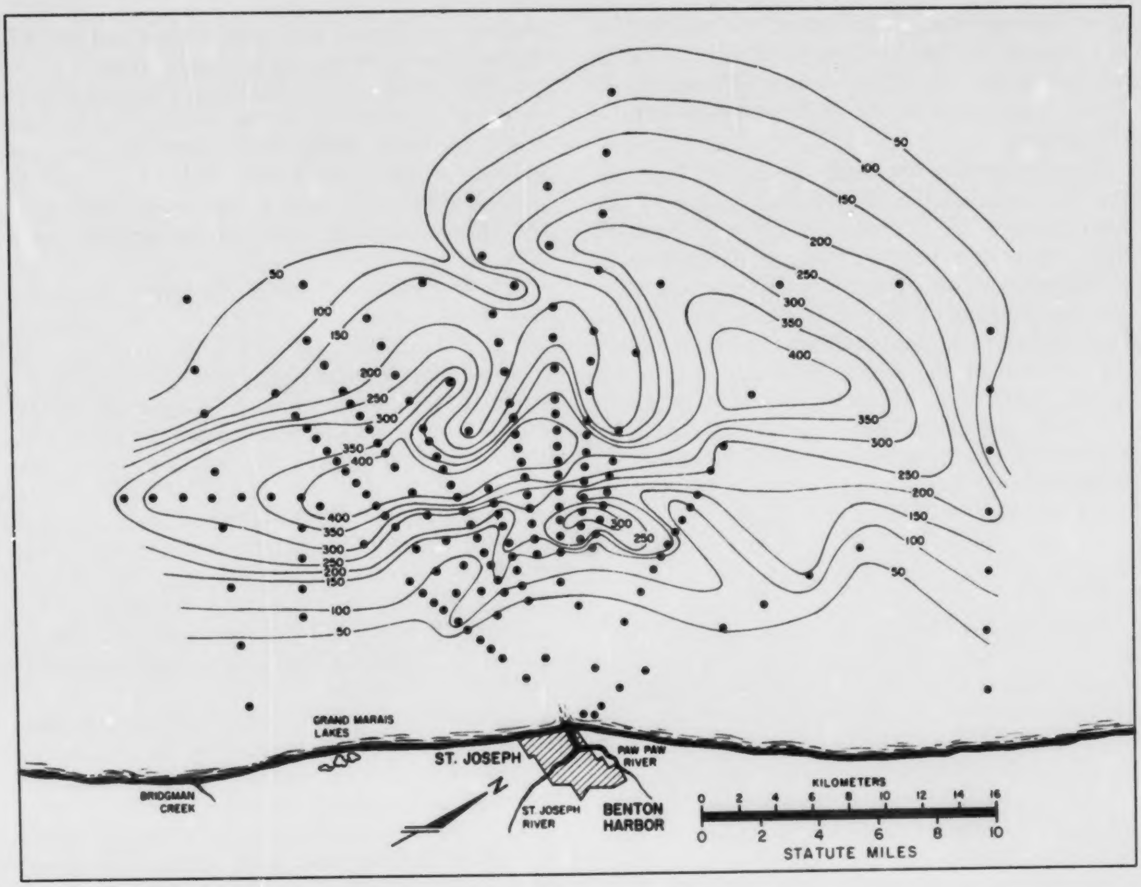
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100
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GRAND MARAIS LAKES
ST. JOSEPH
PAW PAW RIVER
BRIDGMAN CREEK
N
ST JOSEPH RIVER
BENTON HARBOR
KILOMETERS
0 2 4 6 8 10 12 14 16
0 2 4 6 8 10
STATUTE MILES

Figure 2. The deltaic facies produced by the St. Joseph River in Lake Michigan
(Each dot represents a sediment sampling station. The contour lines represent counts per minute of cesium-137 as measured in the field from gamma ray spectra produced by the various sediment samples)

in a previous study (*1*) to identify general areas of relatively high concentrations of fallout cesium-137 in the sediments of Lake Michigan. These areas of high cesium-137 concentrations were influenced by the total watershed of Lake Michigan. This study involved measurements of fallout cesium-137 made in the field on a relatively large number of sediment samples collected near the mouth of the St. Joseph River, the third largest river that empties into Lake Michigan. The accumulation patterns of fallout cesium-137 shown in figure 2 represent the influence of one river on the sediments of Lake Michigan.

Measurements made in the field on samples of bottom sediment for fallout cesium-137 offer a rapid and inexpensive method to determine the location and size of the deltaic facies produced by a river. The method enables an investigator to sample a large area of sediment in a relatively short period of time.

The analysis of a sample for cesium-137 can be completed before the ship arrives at the next sampling station. This rapid analysis of a sample permits decisions to be made in the field concerning areas of sediment to be studied in detail.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, August 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

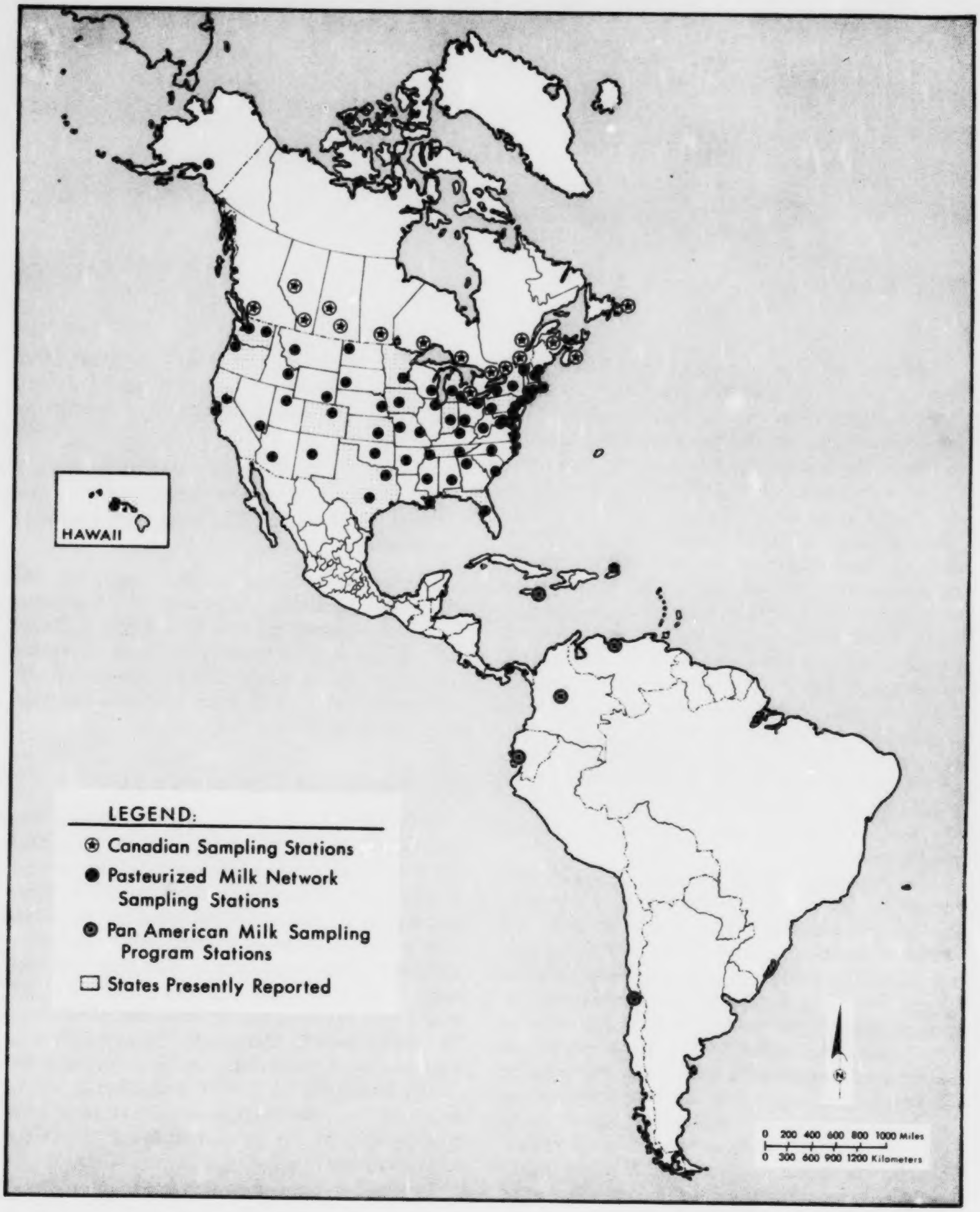
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

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metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 shows whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for those precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Table 2. Concentratons of radionuclides in milk for August 1972 and 12-month period September 1971 through August 1972

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month averag
UNITED STATES						
Ala:	Montgomery[c]	P	NA	7	0	8
Alaska:	Palmer[c]	P	NS	5	NS	10
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	NA	11	0	8
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	1	0	0
	Del Norte	P	10	11	0	10
	Fresno	P	0	2	0	5
	Humboldt	P	3	4	0	8
	Los Angeles	P	0	2	0	5
	Mendocino	P	3	5	0	7
	Sacramento	P	2	2	0	5
	San Diego	P	0	1	10	5
	Santa Clara	P	0	1	0	7
	Shasta	P	2	3	10	8
	Sonoma	P	0	2	0	7
Colo:	Denver[c]	P	NA	5	0	4
	East	R	NS		NS	<0
	Northeast	R	NA		<0	<0
	Northwest	R	NA		<0	<0
	South Central	R	NS		NS	
	Southeast	R	NA		<0	<0
	Southwest	R	NA		<0	<0
	West	R	NA		<0	4
Conn:	Hartford[c]	P	NA	6	0	7
	Central	P	8	7	13	13
Del:	Wilmington[c]	P	NA	8	21	7
D.C:	Washington[c]	P	NA	7	11	6
Fla:	Tampa[c]	P	NS	5	NS	41
	Central	R	NA	5	37	42
	North	R	6	9	17	18
	Northeast	R	4	6	36	34
	Southeast	R	5	6	48	58
	Tampa Bay area	P	NA	5	NA	38
	West	R	7	9	14	17
Ga:	Atlanta[c]	P	NA	9	0	12
Hawaii:	Honolulu[c]	P	2	3	0	1
Idaho:	Idaho Falls[c]	P	3	4	0	0
Ill:	Chicago[c]	P	4	6	0	10
Ind:	Indianapolis[c]	P	NA	6	0	3
	Central	P	6	7	0	11
	Northeast	P	7	7	0	12
	Northwest	P	8	8	0	14
	Southeast	P	7	8	0	12
	Southwest	P	7	9	0	12
Iowa:	Des Moines[c]	P	NA	4	0	1
	Iowa City	P	7	7	10	9
	Des Moines	P	5	6	0	9
	Little Cedar	P	5	7	11	12
	Spencer	P	NS	6	NS	10
Kans:	Wichita[c]	P	NA	8	0	1
	Coffeyville	P	6	8	0	11
	Dodge City	P	4	5	0	9
	Falls City, Nebr.	R	NS	3	NS	8
	Hays	P	5	9	0	8
	Kansas City	P	5	8	0	11
	Topeka	P	5	7	0	8
	Wichita	P	4	8	0	8
Ky:	Louisville[c]	P	NA	8	0	7
La:	New Orleans[c]	P	15	13	0	8
Maine:	Portland[c]	P	NA	6	21	19
Md:	Baltimore[c]	P	NA	7	0	3
Mass:	Boston[c]	P	7	7	11	10
Mich:	Detroit[c]	P	NA	7	0	8
	Grand Rapids[c]	P	NA	7	0	7
	Bay City	P	4	5	0	11
	Charlevoix	P	5	8	10	12
	Detroit	P	0	5	0	9
	Grand Rapids	P	3	5	0	8
	Lansing	P	5	7	0	11
	Marquette	P	3	6	15	21
	Monroe	P	4	3	0	4
	South Haven	P	5	5	0	8
Minn:	Minneapolis[c]	P	NA	8	22	15
	Bemidji	P	NS	7	NS	18
	Duluth	P	15	16	26	28
	Fergus Falls	P	6	7	13	16
	Little Falls	P	27	18	82	50
	Mankato	P	5	5	9	12
	Minneapolis	P	10	13	13	16

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for August 1972 and 12-month period September 1971 through August 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Minn:	Rochester					
	Marshall	P	7	8	11	16
Miss:	Jackson[c]	P	3	6	10	10
Mo:	Kansas City[c]	P	NA	10	0	8
	St. Louis[c]	P	NA	7	0	4
Mont:	Helena[c]	P	NA	7	0	3
Nebr:	Omaha[c]	P	NA	5	0	4
Nev:	Las Vegas[c]	P	NA	5	0	1
N.H:	Manchester[c]	P	NA	2	0	0
N.J:	Trenton[c]	P	NA	8	24	17
N. Mex:	Albuquerque[c]	P	NA	7	15	5
N.Y:	Buffalo[c]	P	NA	2	0	0
	New York City[c]	P	4	6	0	6
	Syracuse[c]	P	NA	8	13	8
	Albany	P	NA	7	0	6
	Buffalo	P	6	6	<0	<0
	Massena	P	5	5	<0	<0
	New York City	P	9	7	<0	<0
	Syracuse	P	9	7	<0	0
N.C:	Charlotte[c]	P	6	4	NA	0
N. Dak:	Minot[c]	P	NA	10	14	8
Ohio	Cincinnati[c]	P	NA	9	0	12
	Cleveland[c]	P	NA	7	0	3
Okla:	Oklahoma City[c]	P	NA	6	0	6
Oreg:	Portland[c]	P	NA	6	0	6
	Baker	P	5	5	0	5
	Coos Bay	P	(e)		0	0
	Eugene	P	(e)		0	3
	Medford	P	(e)		0	1
	Portland composite	P	(e)		0	4
	Portland local	P	(e)		0	6
	Redmond	P	(e)		0	7
	Tillamook	P	(e)		0	0
Pa:	Philadelphia[c]	P	(e)		16	11
	Pittsburgh[c]	P	NA	7	0	3
	Dauphin	P	NA	9	0	5
	Erie	P	10	7	16	12
	Philadelphia	P	11	7	14	10
	Pittsburgh	P	11	5	13	11
R.I:	Providence[c]	P	10	6	11	15
S.C:	Charleston[c]	P	NA	6	18	11
S. Dak:	Rapid City[c]	P	9	9	12	14
Tenn:	Chattanooga[c]	P	NA	7	0	4
	Memphis[c]	P	NA	8	14	9
	Chattanooga	P	NA	7	0	2
	Clinton	R	NA	10	16	13
	Fayetteville	R	NA	9	10 (2)	13
	Kingston	R	NA	9	5 (3)	6
	Knoxville	P	NA	9	5 (2)	8
	Lawrenceburg	R	NA	8	0 (2)	8
	Nashville	P	NS	8	NS	9
	Pulaski	R	NA	8	0	6
	Sequoyah	R	NA	7	14 (2)	8
Tex:	Austin[c]	P	NA	8	24	21
	Dallas[c]	P	NA	3	0	0
	Amarillo	R	NA	6	0	0
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[c]	P	3	4	0	3
Vt:	Burlington[c]	P	NA	6	11	10
Va:	Norfolk[c]	P	NA	8	0	6
Wash:	Seattle[c]	P	NA	5	0	5
	Spokane[c]	P	NA	5	0	7
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	[illegible]
	Longview	R	4	0	15	
	Sandpoint, Idaho	R	5	11	12	16
	Skagit County	R	8	8	0	5
W. Va:	Charleston[c]	P	NA	8	0	5
Wisc:	Milwaukee[c]	P	NA	5	0	6
Wyo:	Laramie[c]	P	NA	4	0	2

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for August 1972 and 12-month period September 1971 through August 1972—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		NA	
Edmonton	P	NA		NA	
British Columbia:					
Vancouver	P	NA		23	24
Manitoba:					
Winnipeg	P	NA		14	21
New Brunswick:					
Fredericton	P	NA		NA	
Newfoundland:					
St. John's	P	NA		41	26
Nova Scotia:					
Halifax	P	NA		16	20
Ontario: Ottawa	P	NA		10	12
Sault Ste. Marie	P	NA		22	27
Thunder Bay	P	NA		NA	
Toronto	P	NA		6	10
Windsor	P	NA		6	9
Quebec: Montreal	P	NA		6	14
Quebec	P	NA		16	26
Saskatchewan:					
Regina	P	NA		8	17
Saskatoon	P	NA		11	16
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal[c]	P	NA	1	0	9
Chile: Santiago	P	0	1	0	1
Colombia: Bogota	P	0	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Mandeville	P	0	3	35	63
Puerto Rico:					
San Juan[c]	P	NA	3	0	5
Venezuela:					
Caracas	P	0	0	0	0
PMN network average[f]		6	6	3	6

[a] P, pasteurized milk
R, raw milk

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When one more than on analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Cesium-137: Colorado—25 pCi/liter
New York—20pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding

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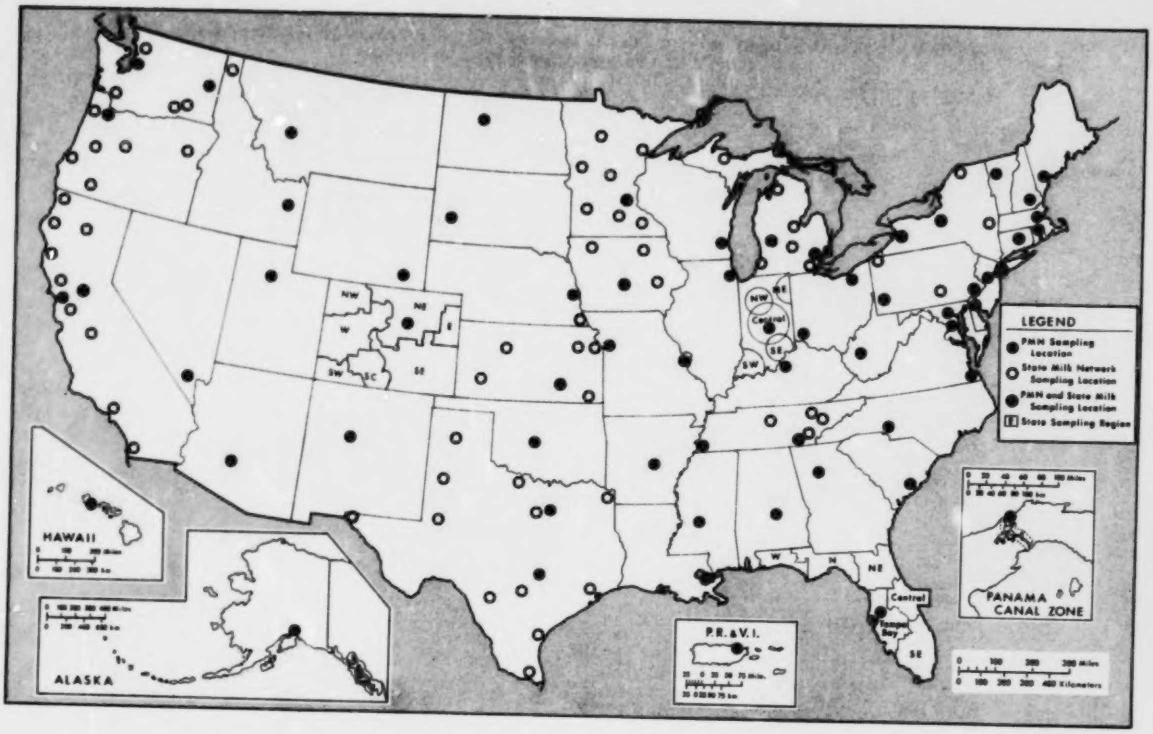
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
● PMN and State Milk Sampling Location
▨ State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for August 1972 and the 12-month period, September 1971 to August 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for August 1972 were below the respective practical reporting levels. Table 3 gives monthly average for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Table 3. Strontium-89, iodine-131, and barium-140 in milk, August 1972

Sampling location		Concentration (pCi/liter)		
		Strontium-89	Iodine-131	Barium-140
Calif:	Shasta (State)	5		
Colo:	Southeast (State)		26	
Kans:	Dodge City (State)	5		
	Kansas City (State)			13
	Wichita (State)	5		
N.Y:	New York City (State)	5		
Colombia:	Bogota	8		

Strontium-90 monthly averages ranged from 0 to 27 pCi/liter in the United States for August 1972, and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 82 pCi/liter in the United States for August 1972, and the highest 12-month average was 58 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (7) and Jamaica.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(*7*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Milk Surveillance Programs, January-March 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The National Environmental Research Center—Las Vegas (NERC-LV) is responsible for conducting radiological safety and environmental surveillance programs in the offsite area surrounding the Nevada Test Site (NTS) in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC)[1] and the Space Nuclear Systems Office (an organizational amalgamation of the AEC and the National Aeronautical and Space Administration). When required, additional surveillance programs are established at locations other than around NTS in support of AEC operations, such as Project Rulison, the Plowshare nuclear explosive engineering experiment near Grand Junction, Colo., in 1970, and in the Cannikin nuclear test on Amchitka Island, Alaska, in 1971. Beginning with this report, the analytical results of milk samples collected for the above programs will be reported in *Radiation Data and Reports.*

The milk surveillance networks operated by the NERC-LV are the routine Milk Surveillance Network (MSN) and the Standby Milk Surveillance Network (SMSN). The MSN, shown in figure 1, consists of 32 regular and 5 alternate locations at which NERC-LV personnel collect 1-gallon milk samples on a monthly basis from family milk cows, commercial pasteurized milk, Grade A raw milk for pasteurization, and Grade A raw milk for local consumption. In the event of a release of

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[1] These programs are operated under a Memorandum of Understanding (No. AT (26-1)–539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

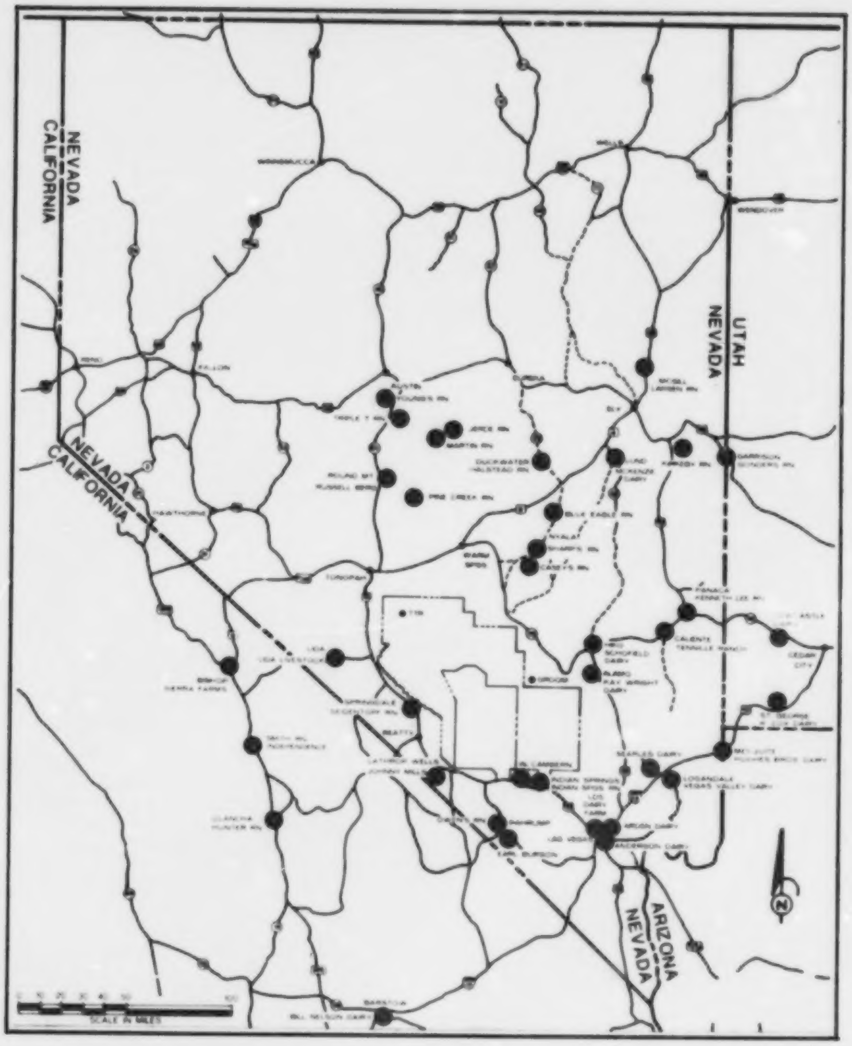
NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA
WELLS
WENDOVER
RENO
FALLON
HAWTHORNE
AUSTIN
YOUNGS RN.
TRIPLE T RN.
JONES RN.
MARTIN RN.
ROUND MT
PINE CREEK RN.
DUCKWATER
EUREKA
ELY
LUND
McKENZIE DAIRY
GARRISON
BLUE EAGLE RN.
NYALA
SHARP'S RN.
CASEY'S RN.
TONOPAH
PANACA
CALIENTE
CEDAR CITY
HIKO
ALAMO
GROOM
LIDA
BISHOP
BEATTY
LATHROP WELLS
INDIAN SPRINGS
LAS VEGAS
LOGANDALE
ST. GEORGE
ARIZONA
NEVADA
N
BARSTOW
SCALE IN MILES

Figure 1. NERC-LV Milk Surveillance Network

radioactivity from the NTS, intensive sampling is conducted in the affected area out to about 300 miles of the NTS to determine radionuclide concentrations in milk, to assess radiation doses that could result from the ingestion of the milk, and to take protective action if required. Milk supplies and producers beyond 300 miles are sampled by the SMSN.

The SMSN (*1*), shown in figure 2, consists of about 185 Grade A milk processing plants which can be requested by telephone to collect raw milk samples representing milksheds sup-

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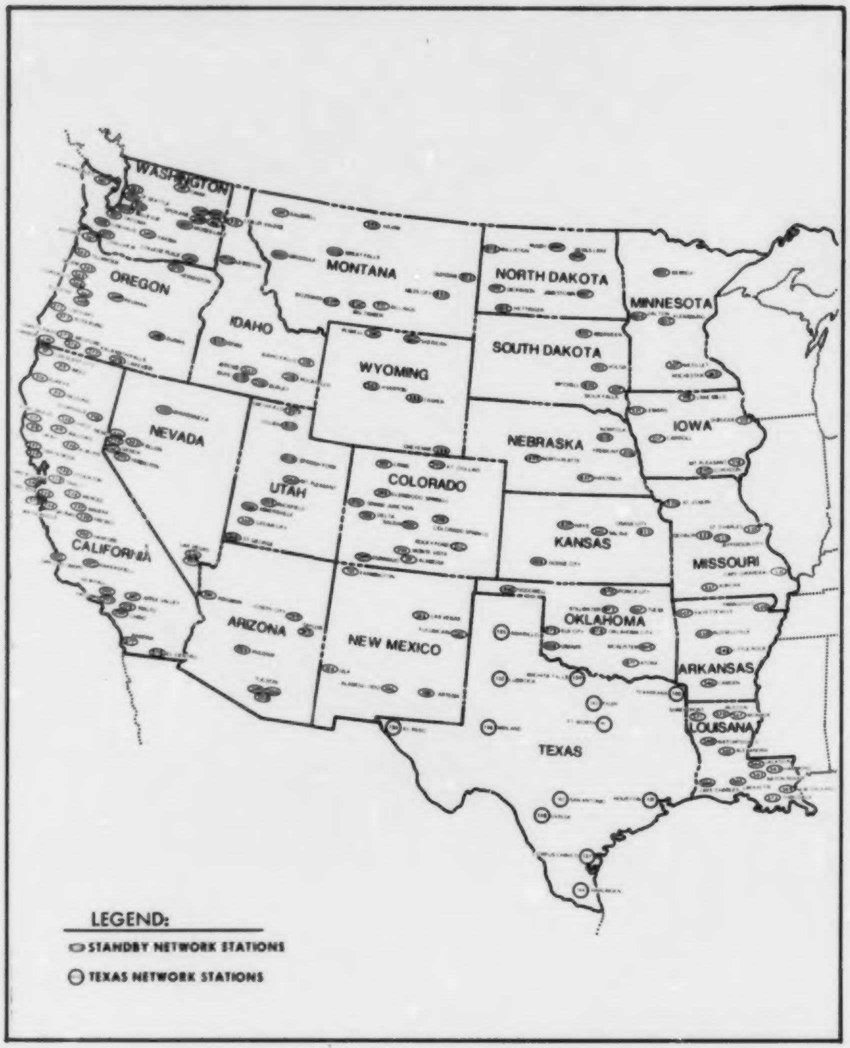
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISANA
LEGEND:
STANDBY NETWORK STATIONS
TEXAS NETWORK STATIONS

Figure 2. NERC-LV Standby Milk Surveillance Network

plying milk to the plants. Samples from the network are collected and mailed to NERC-LV through the cooperation of federal, state, and local government agencies in the event of a release of radioactivity at NTS or other test locations. Periodically, one sample is collected from each station to maintain network readiness and to check the network's reliability. An exception to this is the sampling procedure used in Texas. The Texas State Health Department does its own analysis and forwards the results to NERC-LV.

During readiness checks, only random samples are analyzed for strontium and tritium.

Since the surveillance programs for Project Rulison and the Cannikin Event were completed last year, no milk samples were collected during 1972. The surveillance programs and analytical results prior to January 1972 for these operations are reported separately (*2-4*).

Analytical procedures

All routine samples are analyzed for gamma-emitting radionuclides by gamma spectroscopy and for radiostrontium by radiochemistry procedures. Approximately six samples per month from the most prevalent downwind trajectories from the NTS are also analyzed for tritium. Special or event-related samples are normally gamma scanned. Further analyses depend on whether activity is detected and/or on special requirements of the sampling program.

Table 1 lists the general analytical procedures and detection limits, as described by Johns (*5*), and Lem and Snelling (*6*). For gamma spectroscopy analyses, the samples are placed in 3.5-liter inverted-well Marinelli beakers.. All routine samples are counted for 40 minutes. Special samples collected following known releases of activity are normally counted 20 minutes, but will vary from 10 to 40 minutes depending on radionuclide concentration and sample workload. The activity concentration of each of the detected nuclides at the time of count is calculated and extrapolated to time of collection.

Results

Table 2 lists the analytical results of all milk samples collected from the NERC-LV MSN in January, February, and March 1972. Alternate stations indicated with an (A), are sampled only if milk is unavailable at a regular station.

As a check on network response, a portion of the SMSN in California was requested to send in one raw milk sample each in March. The analytical results of these samples are shown in table 3.

Copies of these results are distributed to EPA Regional Offices and appropriate state agencies prior to publication.

Table 1. Analytical procedures

Type of analysis	Analytical equipment	Counting period (min.)	Analytical procedures	Sample size (liter)	Detection limits (pCi/liter)
Gamma spectroscopy	Gamma spectrometer with a 10 by 10-cm NaI (Tl) crystal with input to 200 channels (0–2 MeV) of 400-channel, pulse-height analyzer	10–40	Radionuclide concentrations quantitated from gamma spectrometer data by computer using an eight element matrix technique	3.5	Generally 10 pCi/liter for most common fallout radionuclides in a simple spectrum
Strontium-89, strontium-90	Low-background thin-window, gas-flow proportional counter with a 5.7 cm diameter window (80 μg/cm²)	50	Chemical separation by ion exchange. Separated sample counted successively; activity calculated by simultaneous equations	1.0	[a] Strontium-89 = 5 [a] Strontium-90 = 2
Tritium	Automatic liquid scintillation counter with output printer	100	Sample prepared by distillation	.005	[a,b] = 320.

[a] The detection limit for a given sample is defined as that concentration which is equal to the 2-sigma counting error.

[b] The detection limit for samples analyzed during February and thereafter was = 220 pCi/liter.

Table 2. Milk surveillance results, January, February, and March 1972

Location	Map number	Date collected (1972)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	1/6	11	<10	<2	2 ±1	NA
		2/9	11	<10	<2	<1	NA
		3/6	11	<10	<2	<1	NA
Hinkley:							
Bill Nelson Dairy	13	1/5	12	<10	2 ±1	<1	NA
		2/8	12	<10	<2	<1	NA
		3/7	12	<10	<2	<1	NA
Independence:							
Smith Ranch	14	NS					
		2/9	13	<10	2 ±2	2 ±2	NA
		3/7	13	<10	6 ±1	<1	NA
Olancha:							
Hunter Ranch	30	1/5	13	[c] <100	<2	4 ±1	NA
		2/7	13	[c] <100	2 ±2	2 ±1	NA
		3/5	13	[c] <100	<2	3 ±1	NA
Nevada:							
Alamo:							
Wright Dairy	1	1/13	12	10	<2	4 ±2	NA
		2/8	12	<10	<2	2 ±2	NA
		3/7	12	<10	<2	3 ±1	NA
Austin:							
Triple T Ranch	2	1/12	13	<10	<2	3 ±2	620 ±320
		2/8	13	10	<2	4 ±2	610 ±270
		3/7	13	10	<2	2 ±1	350 ±200
Young's Ranch (A)	3	NS					
		NS					
		NS					
Belmont:							
Pine Creek Ranch	4	NS					
		NS					
		NS					
Caliente:							
Young's Ranch	6	NS					
		NS					
		NS					
Currant:							
Blue Eagle Ranch	7	NS					
		2/8	13	20	<2	3 ±2	NA
		3/8	13	40	<2	3 ±2	NA
Duckwater:							
Halstead Ranch	8	NS					
		NS					
		3/8	13	20	<2	5 ±2	NA
Eureka:							
Jerde Ranch (A)	9	NS					
		NS					
		NS					
Martin Ranch	10	1/7	13	20	5 ±3	4 ±2	NA
		2/7	13	20	<3	5 ±2	NA
		3/6	13	20	<3	10 ±2	NA
Hiko:							
Schofield Dairy	12	1/10	12	<10	<2	3 ±1	310
		2/8	12	<10	<2	3 ±2	260
		3/7	12	10	<2	4 ±1	840 ±260
Indian Springs:							
Cambern Ranch (A)[c]	16	NS					
		2/8	13	<10	1 ±1	<1	NA
		NS					
Indian Springs Ranch	15	NS					
		NS					
		NS					
Las Vegas:							
Anderson Dairy	17	1/4	11	<10	<2	3 ±1	NA
		2/16	11	<10	<2	2 ±2	NA
		NS					
Arden Dairy	18	1/4	11	<10	<2	<1	NA
		2/16	11	<10	<2	2 ±1	NA
		NS					
Las Vegas:							
LDS Dairy Farm	19	1/4	12	<10	<2	<1	<290
		2/16	12	<10	<1	2 ±1	<190
		NS					
Lathrop Wells:							
Mills Ranch	20	1/5	13	<10	2 ±2	<1	NA
		2/9	13	<10	<1	<1	NA
		3/8	13	<10	<2	<1	NA
Lida:							
Lida Livestock Company	21	1/9	13	<10	<2	4 ±2	NA
		2/7	13	<10	<2	2 ±2	NA
		3/5	13	<10	<1	<1	NA
Logandale:							
Vegas Valley Dairy	22	1/10	12	<10	[d]NA	[d]NA	NA
		2/7	12	<10	[d]NA	[d]NA	NA
		3/13	12	<10	<2	3 ±1	NA

See footnotes at end of table.

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Table 2. Milk surveillance results, Janary February, and March 1972—continued

Location	Map number	Date collected (1972)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
Lund:							
McKenzie Dairy	23	1/11	12	<10	<2	4 ±2	<310
		2/9	12	<10	3 ±2	<2	<310
		3/9	12	10	<2	3 ±1	<250
McGill:							
Larsen Ranch	24	NS					
		NS					
		3/9	13	<10	<1	2 ±1	NA
Mesquite:							
Hughes Bros Dairy	25	1/11	12	<10	<2	2 ±1	<290
		2/9	12	<10	<1	2 ±1	730 ±250
		3/13	12	<10	<1	2 ±1	<200
Moapa:							
Searles Dairy	26	1/10	12	<10	<2	2 ±2	NA
		2/8	12	<10	<2	3 ±2	NA
		3/7	12	<10	<2	3 ±1	NA
Nyala:							
Sharp's Ranch	28	1/11	13	10	<2	2 ±2	<290
		2/10	13	<10	<2	5 ±2	<250
		3/8	13	<10	<2	4 ±2	<200
Casey's Ranch (A) [e]	29	NS					
		NS					
		NS					
Pahrump:							
Earl Burson (A)	32	NS					
		NS					
		NS					
Owens Ranch	31	1/3	13	<10	<1	2 ±1	NA
		2/9	13	<10	1 ±1	<1	NA
		3/10	13	<10	<1	<1	NA
Panaca:							
Kenneth Lee Ranch	33	1/11	13	<10	<2	2 ±1	NA
		2/9	13	<10	<2	2 ±1	NA
		3/8	13	<10	<2	<2	NA
Round Mt:							
Russell Berg	34	NS					
		NS					
		3/7	13	<10	<3	9 ±2	NA
Shoshone:							
Kirkeby Ranch	35	1/12	13	<10	<3	5 ±2	NA
		NS					
		NS					
Springdale:							
McCurdy Ranch	36	1/6	13	[c] <100	<2	2 ±1	NA
		2/9	13	<10	<2	<1	NA
		3/8	13	<10	<1	2 ±1	NA
Utah:							
Garrison:							
Gonders Ranch	11	1/12	13	<10	<2	3 ±2	NA
		2/10	13	<10	<2	3 ±2	NA
		3/7	13	<10	<2	2 ±1	NA
Newcastle:							
Newcastle Dairy	27	1/11	12	<10	<2	2 ±2	NA
		2/9	12	<10	<2	2 ±1	NA
		3/15	12	<10	<2	4 ±1	NA
St. George:							
R. Cox Dairy	37	1/10	12	<10	<2	3 ±2	NA
		2/8	12	<10	<2	4 ±1	NA
		3/14	12	<10	<2	3 ±1	NA

[a] 11, pasteurized milk.
12, raw milk from Grade A producer(s).
13, raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size.
[d] Not analyzed because sample was sour.
[e] (A) alternate milk sampling station.
NA, not analyzed.
NS, no sample.

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Table 3. Standby Milk Surveillance Network results

Location	Map number	Date collected 1972	Radionuclide concentrations[a] (pCi/liter)			
			^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:						
Auburn:						
Lone Star Dairy	326	3/28	<10	NA	NA	NA
Chico:						
Quality Dairy	320	3/27	<10	<3	4 ±1	<220
Fort Bragg:						
Denevi Dairy	317	3/27	[b],[c] <100	NA	NA	NA
Fresno:						
St. College Creamery	339	3/27	<10	<2	2 ±1	<220
Madera:						
Madera Quality Dairy	337	3/26	<10	NA	NA	NA
Merced:						
Sunshine Dairy Farms	336	3/27	<10	NA	NA	NA
Redding:						
McColl's Dairy Prod	315	3/27	<10	<3	2 ±1	<220
Salinas:						
Blue Ribbon Dairy	334	3/27	[b] <100	<2	<1	<200
San Jose:						
Pleasant Hill Dairy	330	3/26	<10	NA	NA	NA
Santa Clara:						
Edelweiss Dairies	348	3/29	<10	NA	NA	NA
Santa Rosa:						
Arlington Farms	323	3/27	<10	<3	2 ±1	<220
Burbank Dairy	324	3/26	<10	NA	NA	NA
Susanville:						
Morning Glory Dairy	316	3/26	<10	<3	5 ±2	<220
Tracy:						
Deuel Voc. Inst.	350	3/27	<10	NA	NA	NA
Watsonville:						
Monte Vista Dairy	579	3/27	<10	NA	NA	NA
	579	3/28	<10	NA	NA	NA
Willits:[c]						
Ridgewood Ranch Dairy	None	3/27	<10	<4	6 ±2	240 ±200

[a] Two-sigma counting error provided when available.
[b] Small sample size.
[c] New sampling location.
NA, not analyzed.

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(*1*) SHARPE, T. J. and J. L. STEIN. Standby Milk Surveillance Network. Radiol Health Data 8:379-382 (August 1970).

(*2*) PAYNE, D. W. and R. F. GROSSMAN, Off-Site Radiological Safety Program for Project Rulison Re-Entry Portion of Phase III, SWRHL-115r. Western Environmental Research Laboratory, EPA, Las Vegas, Nev. (to be published).

(*3*) BOYSEN, G. Off-Site Radiological Safety Program for Project Rulison Flaring Portion of Phase III, SWRHL-116r. Western Environmental Research Laboratory, EPA, Las Vegas, Nev. (to be published).

(*4*) FORT, C. W. and D. T. WRUBLE. Final Report of Off-Site Radiological Safety for the Cannikin Event, November 6, 1971, NERC-LV-539-2. Western Environmental Research Laboratory, EPA, Las Vegas, Nev. (to be published).

(*5*) JOHNS, F. B. Southwestern Radiological Health Handbook of Radiochemical Analytical Methods, SWRHL-11. Southwestern Radiological Health Laboratory, Las Vegas, Nev. (March 1970).

(*6*) LEM, P. N. and R. N. SNELLING. Southwestern Radiological Health Laboratory Data Analysis and Procedures Manual, SWRHL-21. Southwestern Radiological Health Laboratory, Las Vegas, Nev. (March 1971).

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Foods and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
Carbon-14 in Total Diet and Mlik	July–December 1971	May 1972
Connecticut Standard Diet	January–December 1970	December 1971
Institutional Total Diet	October–December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January–December 1971	November 1972
Strontium-90 in Tri-City Diets	January–December 1970	November 1971

Estimated Daily Intake of Radionuclides in California Diets, January-June 1971

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 3 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

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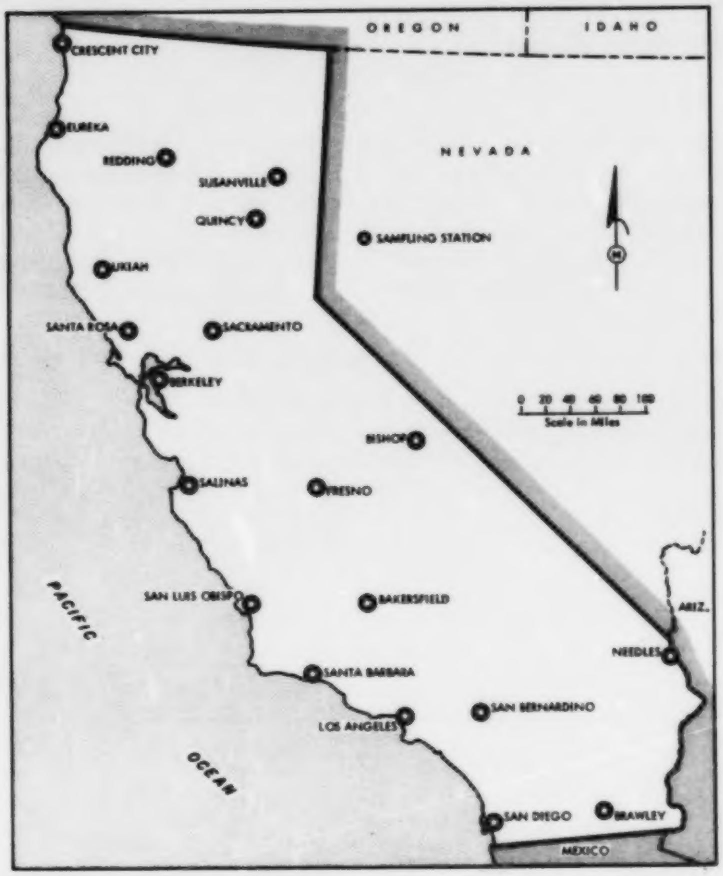
OREGON
IDAHO
NEVADA
CRESCENT CITY
EUREKA
REDDING
SUSANVILLE
QUINCY
SAMPLING STATION
N
UKIAH
SANTA ROSA
SACRAMENTO
BERKELEY
0 20 40 60 80 100
Scale in Miles
BISHOP
SALINAS
FRESNO
PACIFIC
SAN LUIS OBISPO
BAKERSFIELD
ARIZ.
NEEDLES
SANTA BARBARA
SAN BERNARDINO
LOS ANGELES
OCEAN
SAN DIEGO
BRAWLEY
MEXICO

Figure 1. California diet sampling stations

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, strontium, and sodium.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (January-March 1971) and table 2 (April-June 1971).

Table 1. Estimated daily intake of radionuclides in California diets,[a] January–March 1971

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.2	0	8	0.8	0	7	19	0	4.4	3.0	1.1
Berkeley	2.1	2	6	1.6	3	4	17	0	4.1	3.1	.8
Bishop	2.0	0	6	.8	3	5	17	0	3.1	3.1	.8
Brawley	2.4	1	8	1.3	0	6	18	1	4.8	3.0	1.4
Crescent City	2.2	3	12	1.3	5	4	18	0	4.1	3.2	.9
Eureka	2.2	2	7	1.0	1	4	17	0	4.0	2.8	.9
Fresno	1.9	1	5	1.5	0	5	18	0	2.7	2.7	1.0
Los Angeles	2.0	2	5	1.0	0	3	20	0	2.8	3.4	.8
Needles	2.2	2	6	.6	0	2	18	0	2.9	2.7	1.1
Quincy	2.3	0	7	1.4	0	1	17	0	2.9	2.5	.7
Redding	2.0	2	7	1.1	0	1	16	2	3.0	2.8	1.5
Sacramento	2.2	4	5	.9	1	5	13	0	2.9	4.4	.9
Salinas	2.5	0	7	1.0	0	5	19	0	6.7	3.6	.8
San Bernardino	2.3	0	7	.7	1	9	21	3	4.3	3.4	1.2
San Diego	2.2	3	5	1.1	0	5	20	0	3.1	3.2	1.2
San Luis Obispo	1.9	7	5	1.2	3	8	15	0	2.9	4.1	1.2
Santa Barbara	2.3	2	7	.9	0	5	15	0	3.0	3.6	1.0
Santa Rosa	1.6	3	5	1.0	0	8	12	0	2.2	3.3	.6
Susanville	1.5	2	4	1.0	0	5	9	0	2.1	3.1	.6
Ukiah	2.6	3	6	1.0	0	4	17	0	2.9	3.3	1.2

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

Table 2. Estimated daily intake of radionuclides in California diets,[a] April–June 1971

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.1	3	4	0.8	0	7	13	0	2.9	4.0	1.0
Berkeley	1.7	2	4	1.1	0	5	15	0	2.6	3.8	.8
Bishop	1.8	3	3	.8	0	7	17	0	2.7	2.5	.6
Brawley	2.1	4	5	.5	0	2	19	0	2.6	4.0	.7
Crescent City	2.3	39	23	1.4	17	0	18	0	4.1	5.5	1.4
Eureka	2.0	7	6	.9	4	2	17	0	2.5	4.1	.6
Fresno	2.1	3	5	2.1	1	6	17	0	3.1	3.1	1.3
Los Angeles	1.9	2	7	1.3	3	4	17	0	2.7	3.8	.7
Needles	2.4	4	5	.7	0	7	15	0	2.9	3.3	.9
Quincy	2.1	4	5	1.4	1	4	19	0	3.1	3.5	.7
Redding	1.6	2	4	.9	1	3	16	0	2.1	2.7	.9
Sacramento	2.7	5	8	1.2	1	8	18	0	3.5	5.3	1.3
Salinas	2.3	0	6	1.0	2	4	17	0	2.9	6.[illegible]	.8
San Bernardino	2.2	6	4	1.4	0	5	20	0	3.2	4.4	1.3
San Diego	2.2	0	7	.9	0	8	18	0	3.2	2.8	1.0
San Luis Obispo	1.9	4	5	1.6	0	11	17	0	3.1	3.5	1.3
Santa Barbara	2.0	1	4	.9	0	5	17	0	3.0	2.8	.8
Santa Rosa	1.8	1	7	.2	3	2	13	0	2.2	3.4	.8
Susanville	1.1	2	3	.7	2	1	8	0	1.3	2.8	.3
Ukiah	1.9	2	4	1.3	0	8	19	0	2.9	3.2	1.3

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through June 1971 is given in figures 2 and 3.

Recent coverage in *Radiation Data and Reports*

Period	Issue
July–December 1970	November 1971

REFERENCE

(*1*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley, Calif. 94704.

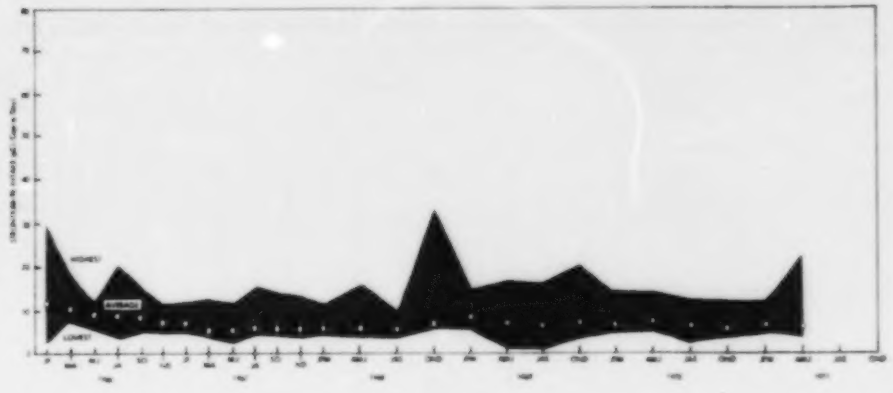

Figure 2. Averages and ranges of daily strontium-90 intake in California diets

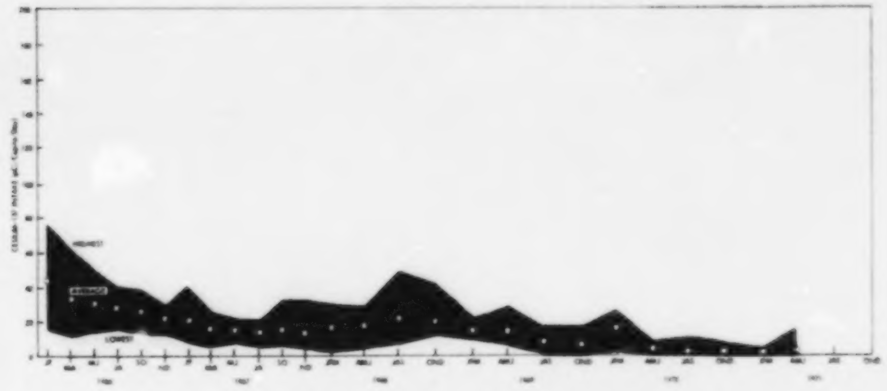

Figure 3. Averages and ranges of daily cesium-137 intake in California diets

Estimated Daily Intake of Radionuclides in Connecticut Standard Diet January-December 1971

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analyses are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Table 1. Foods included in standard diet

Bread, white—8 slices
Butter, ½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks
Cookies—4
Cottage cheese— ⅔ cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice cream—½ pint
Lettuce, washed—4,5 leaves
Milk—3 cups
Oatmeal—uncooked—43 grams
Orange—1
Peanut butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Cesium-137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from January through December 1971. Results representative

Table 2. Radionuclide concentrations in Connecticut standard diet,[a] January–December 1971

Month (1971)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
January	2.2	5.7	20
February	2.1	5.7	20
March	2.5	6.4	20
April	2.1	6.5	30
May	2.2	7.1	40
June	2.0	6.8	30
July	2.4	7.7	10
August	2.1	8.6	20
September	2.0	8.0	10
October	2.0	7.8	10
November	(b)	(b)	(b)
December	(b)	(b)	(b)

[a] All strontium-89 values were below the detectable level for this period.
[b] Teenage diet discontinued as of November 1971.

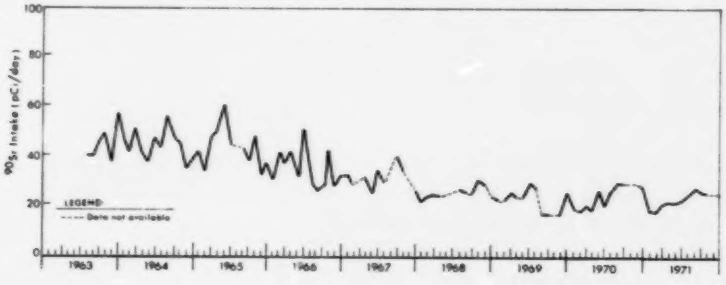

Figure 1. Strontium-90 intake in Connecticut standard diet 1963–December 1971

of the total daily intake for the radionuclides observed are presented in table 3.

In order to evaluate general trends, the strontium-90 and cesium-137 daily intakes are plotted as a function of time in figures 1 and 2.

REFERENCE

(*1*) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] January–December 1971

Month (1971)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	7.1	18.4	70
February	6.8	18.0	50
March	8.0	20.2	60
April	7.0	21.7	85
May	6.7	21.5	120
June	6.5	21.7	100
July	7.6	24.6	30
August	6.7	26.9	70
September	6.4	25.5	50
October	6.3	24.2	30
November[b]			
December[b]			

[a] All strontium-89 values were below the detectable level for this period.
[b] Teenage diet discontinued as of November 1971.

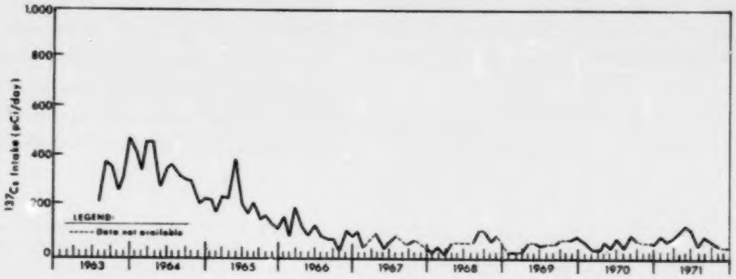

Figure 2. Cesium-137 intake in Connecticut standard diet 1963–December 1971

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1970	December 1971

Strontium-90 in Tri-City Diets, January-December 1971

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (*HASL*). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department

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[1] Data from Fallout Program Quarterly Summary Report, HASL 243, 246, and 249. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

of Agriculture in their 1955 Household Diet Survey (*1*). A detailed description of the aims and methods of the *HASL* diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*2*).

In 1968, two changes were made in the program. The first change was the suspension of the collection and analysis of foods purchased in Chicago. Previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, January–March 1971[a]

Food category	Diet (kg/a)	Calcium (g/a)	New York City February 1971 Strontium-90 (pCi/kg)	New York City February 1971 Strontium-90 (pCi/a)	San Francisco March 1971 Strontium-90 (pCi/kg)	San Francisco March 1971 Strontium-90 (pCi/a)
Dairy products	200	216.0	8.9	1,790	2.9	583
Fresh fruit	59	9.4	15.4	907	3.5	205
Fresh vegetables	48	18.7	11.9	571	1.5	75
Root vegetables	10	3.8	8.3	83	5.4	54
Potatoes	38	3.8	7.3	277	1.4	54
Macaroni	3	.6	4.4	13	2.9	9
Rice	3	1.1	2.2	7	.8	2
Fruit juices	28	2.5	3.9	108	1.6	46
Canned vegetables	22	4.4	11.8	260	3.4	75
Canned fruit	11	.6	1.3	14	1.3	15
Dried beans	3	2.1	50.9	153	21.0	63
Flour	34	6.5	7.9	267	5.9	202
Bakery products	44	53.7	4.9	214	4.4	192
Whole grain products	11	10.3	12.3	135	8.5	94
Fresh fish	8	7.6	.4	3	.4	3
Shellfish	1	1.6	1.2	1	.6	1
Poultry	20	6.0	.7	13	.6	11
Meat	79	12.6	.5	42	.3	23
Eggs	15	8.7	2.0	30	1.7	26
Annual intake (pCi/a)		370		4,888		1,733
Daily intake (pCi/g Ca)				13.2		4.7

[a] No samples for January 1971.

Table 2. Average dietary consumption and strontium-90 intake in Tri-City diet, April–June 1971[a]

Food category	Diet (kg/a)	Calcium (g/a)	New York City May 1971 Strontium-90 (pCi/kg)	New York City May 1971 Strontium-90 (pCi/a)	San Francisco June 1971 Strontium-90 (pCi/kg)	San Francisco June 1971 Strontium-90 (pCi/a)
Dairy products	200	216.0	9.3	1,860	2.9	583
Fresh fruit	59	9.4	14.2	840	2.6	151
Fresh vegetables	48	18.7	19.0	914	2.0	95
Root vegetables	10	3.8	6.3	63	3.3	33
Potatoes	38	3.8	6.8	259	.6	21
Macaroni	3	.6	4.5	14	3.6	11
Rice	3	1.1	1.9	6	2.4	7
Fruit juices	28	2.5	3.5	99	2.8	79
Canned vegetables	22	4.4	2.3	50	3.1	68
Canned fruit	11	.6	1.6	18	1.7	19
Dried beans	3	2.1	8.4	25	17.2	52
Flour	34	6.5	7.7	263	4.9	166
Bakery	44	53.7	8.5	372	3.8	166
Whole grain products	11	10.3	13.2	145	6.5	71
Fresh fish	8	7.6	1.2	10	.3	2
Shellfish	1	1.6	1.1	1	.4	<1
Poultry	20	6.0	.9	19	1.1	21
Meat	79	12.6	.6	48	.7	52
Eggs	15	8.7	2.2	33	2.3	34
Annual intake (pCi/a)		570		5,039		1,632
Daily intake (pCi/g Ca)				13.6		4.4

[a] No samples for April 1971.

City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Sur-

Table 3. Average dietary consumption and strontium-90 intake in Tri-City diet, July–Sep ember 1971[a]

Food category	Diet (kg/a)	Calcium (g/a)	New York City August 1971		San Francisco September 1971	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	7.9	1,586	1.5	292
Fresh fruit	59	9.4	2.7	157	2.1	121
Fresh vegetables	48	18.7	20.2	970	1.9	89
Root vegetables	10	3.8	3.2	32	3.7	37
Potatoes	38	3.8	4.1	156	.8	28
Macaroni	3	.6	6.2	19	3.5	11
Rice	3	1.1	2.9	9	2.7	8
Fruit juices	28	2.5	3.6	100	2.7	75
Canned vegetables	22	4.4	9.4	207	3.8	83
Canned fruit	11	.6	1.2	13	1.1	12
Dried beans	3	2.1	18.1	54	13.5	41
Flour	34	6.5	10.6	359	3.7	125
Bakery products	44	53.7	5.8	254	3.8	168
Whole grain products	11	10.3	17.9	197	7.8	86
Fresh fish	8	7.6	.3	2	.7	5
Shell fish	1	1.6	2.5	2	1.4	1
Poultry	20	6.0	1.4	27	1.0	19
Meat	79	12.6	1.0	76	.6	49
Eggs	15	8.7	2.9	43	1.5	23
Annual intake (pCi/a)		370		4,264		1,273
Daily intake (pCi/g Ca)				11.5		3.4

[a] No samples for July 1971.

Table 4. Average dietary consumption and strontium-90 intake in Tri-City diet, October–December 1971[a]

Food category	Diet (kg/a)	Calcium (g/a)	New York City November 1971		San Francisco December 1971	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	6.8	1,363	1.2	248
Fresh fruit	59	9.4	13.1	771	2.1	121
Fresh vegetables	48	18.7	15.6	747	3.6	172
Root vegetables	10	3.8	11.3	113	6.0	60
Potatoes	38	3.8	10.1	385	1.1	42
Macaroni	3	.6	4.2	13	2.8	8
Rice	3	1.1	2.7	8	2.0	6
Fruit juices	28	2.5	3.8	107	2.4	68
Canned vegetables	22	4.4	7.1	156	2.8	62
Canned fruit	11	.6	1.1	12	1.0	11
Dried beans	3	2.1	18.9	57	9.7	29
Flour	34	6.5	9.2	314	.4	15
Bakery products	44	53.7	5.8	257	3.2	140
Whole grain products	11	10.3	10.7	118	7.1	78
Fresh fish	8	7.6	.3	2	.3	2
Shellfish	1	1.6	1.2	1	.7	1
Poultry	20	6.0	.9	18	.4	8
Meat	79	12.6	.4	32	.3	24
Eggs	15	8.7	1.4	21	1.0	15
Annual intake (pCi/a)		370		4,495		1,110
Daily intake (pCi/g Ca)				12.1		3.0

[a] No samples for October 1971.

vey (*3*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for 1971 in New York City and San Francisco.

Results for January–December 1971 are presented in tables 1 through 4. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) RIVERA, J. and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–137. Office of Technical Services, U.S. Atomic Energy Commission, New York, N.Y. (July 1, 1964).

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, spring 1965, A Preliminary Report. USDA, ARS 62–16 (August 1967).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1970	November 1971

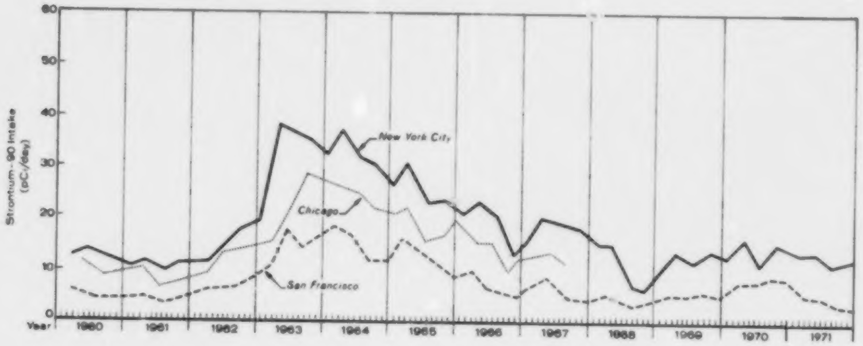

Figure 1. Daily intake of strontium-90 in Tri-City diets, 1960–December 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1970	December 1971
Michigan	January–June 1970	November 1971
Minnesota Municipal Water	July 1970–June 1971	November 1972
New York	July–December 1970 and January–June 1971	May 1972
North Carolina	1969	January 1972
Radiostrontium in Tap Water, *HASL*	July–December 1971	November 1972
Washington	July 1969–June 1970	March 1972
Water Surveillance Programs	January–March 1972	December 1972

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, April 1972

Office of Air and Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Air and Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radio-

Table 1. Gross radioactivity in U.S. surface waters, April 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River:					
Kingston, Tenn	3	<0.2	<0.2	4	7
		<.2	.5	4	6
		.3	<.4	<2	6
Colorado River:					
DeBeque, Colo	1	.8	2.3	<2	6
Moab, Utah Highway bridge	4	1.7	9.6	7	35
		2.3	5.5	6	15
		<1.8	<3.6	5	22
		6.1	4.9	18	9
Above Mill Creek	4	1.5	10.8	9	21
		2.8	12.2	10	33
		1.5	7.4	17	28
		9.3	3.9	19	9
Dolores River:					
Bedrock, Colo	4	.3	4.7	5	14
		2.1	2.9	12	17
		.7	1.8	3	4
		11.0	1.0	37	6
Gateway, Colo	4	.4	5.6	5	28
		1.5	7.0	5	26
		.6	3.9	6	26
		6.6	13.4	15	42
Mississippi River:					
Burlington, Iowa	1	<.5	1.7	3	8
Ohio River:					
Cincinnati, Ohio (Dam #27)	4	.3	.5	<2	3
		5.5	.4	12	3
		8.1	.6	31	4
		2.0	.6	17	7
Roanoke River:					
John Kerr Dam, Va	4	.3	<.2	4	3
		<.3	<.3	<2	4
		<.3	<.3	<2	3
		<.4	<.5	2	4
San Juan River:					
Bluff, Utah	1	7.7	1.5	30	6
San Miguel River:					
Uravan, Colo	3	<.3	1.9	<2	5
		<.4	2.0	3	<4
		<.5	<2.3	2	7
Below Uravan, Colo	4	.7	11.8	4	16
		.6	7.0	4	17
		<.6	2.8	4	11
		1.0	6.8	6	23
Naturita, Colo	4	<.2	1.1	5	12
		<.3	1.2	<2	7
		<1.0	<2.0	2	6
		.8	.9	6	9
St. Lawrence River:					
Massena, N.Y	4	<.2	<.4	5	7
		<.3	.6	<2	4
		<.4	<.8	2	6
		<.4	<.7	2	6
White River:					
Watson, Utah	1	<2.3	<2.0	5	4

activity analyses are performed in the centralized laboratories of the Office of Air and Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, this activity was resumed as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from 10 rivers during April 1972. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Water Surveillance Programs, January-March 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The National Environmental Research Center—Las Vegas (NERC-LV) is responsible for conducting a radiological safety and environmental surveillance program in the offsite area surrounding the Nevada Test Site (NTS) in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC)[1] and the Space Nuclear Systems Office (an organizational amalgamation of the AEC and the

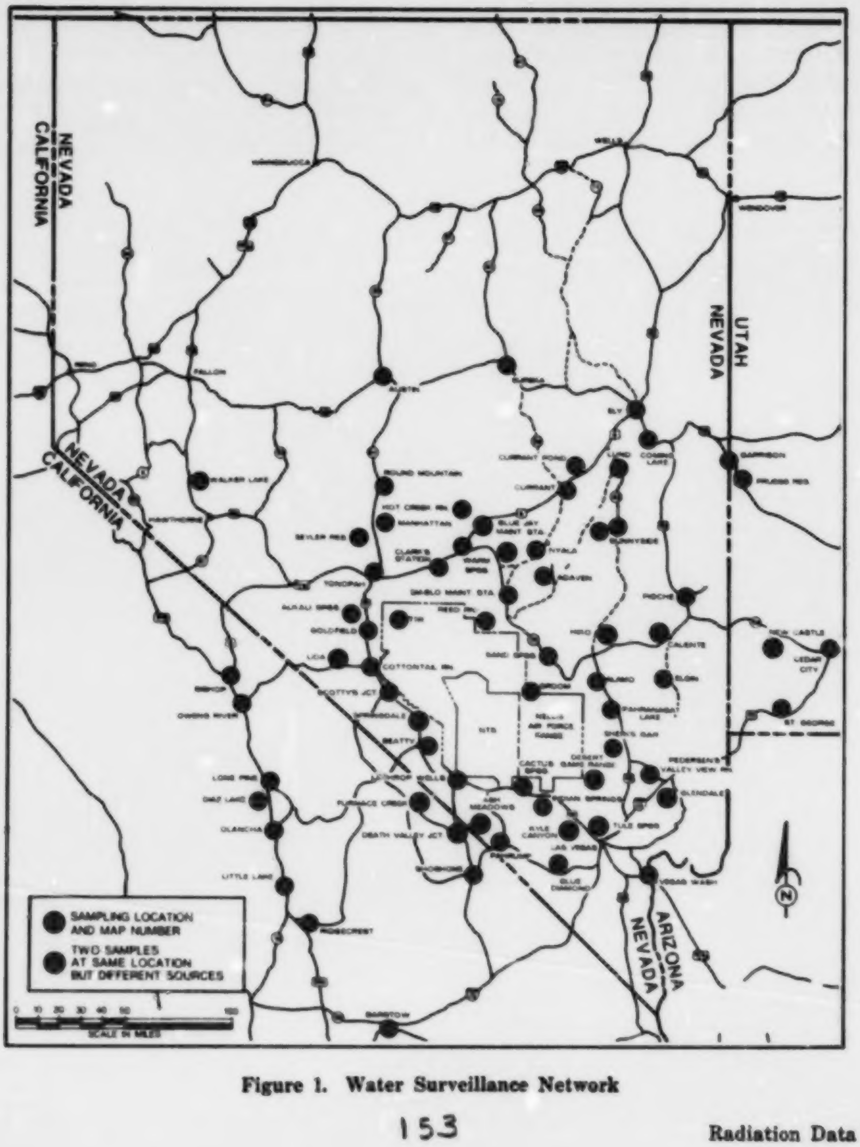
NEVADA
CALIFORNIA
UTAH
NEVADA
ARIZONA
NEVADA
AUSTIN
EUREKA
ELY
COMINS LAKE
GARRISON
CURRANT
ROUND MOUNTAIN
HOT CREEK RN
MANHATTAN
BLUE JAY MAINT STA
TYBO
SUNNYSIDE
CLARK'S STATION
WARM SPGS
TONOPAH
DIABLO MAINT STA
PIOCHE
ALKALI SPGS
REED RN
GOLDFIELD
HIKO
CALIENTE
NEW CASTLE
CEDAR CITY
LIDA
COTTONTAIL RN
SAND SPGS
ALAMO
ELGIN
SCOTTY'S JCT
PAHRANAGAT LAKE
ST GEORGE
SPRINGDALE
NTS
NELLIS AIR FORCE RANGE
BEATTY
DESERT GAME RANGE
PEDERSEN'S
VALLEY VIEW RN
CACTUS SPGS
LATHROP WELLS
LONE PINE
OLANCHA
FURNACE CREEK
ASH MEADOWS
INDIAN SPRINGS
GLENDALE
DEATH VALLEY JCT
KYLE CANYON
TULE SPGS
LAS VEGAS
SHOSHONE
BLUE DIAMOND
VEGAS WASH
LITTLE LAKE
RIDGECREST
BARSTOW
OWENS RIVER
BISHOP
WALKER LAKE
FALLON
RENO
HAWTHORNE
WELLS
WENDOVER
WINNEMUCCA
SAMPLING LOCATION AND MAP NUMBER
TWO SAMPLES AT SAME LOCATION BUT DIFFERENT SOURCES
0
10
20
30
40
50
100
SCALE IN MILES
N

Figure 1. Water Surveillance Network

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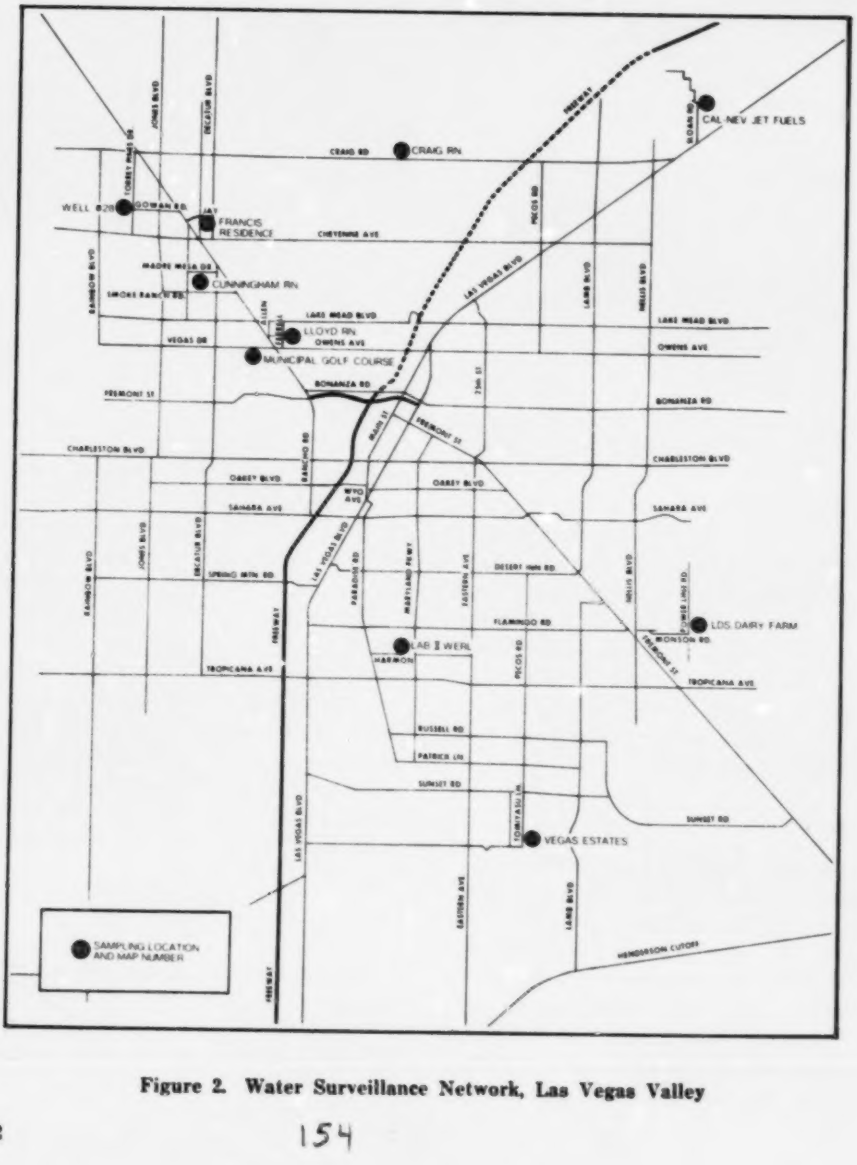
[1] These programs are operated under a Memorandum of Understanding (NO. AT (26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

National Aeronautical and Space Administration). When required, additional surveillance programs are established at locations other than around the NTS in support of AEC operations, such as Project Rulison, the Plowshare nuclear explosive engineering experiment near Grand Junction, Colo. in 1970, and the Cannikin nuclear test on Amchitka Island, Alaska in 1971. Beginning with this report, the analytical results of water samples collected for the above programs will be reported in *Radiation Data and Reports.*

The Water Surveillance Network, operated in offsite areas around the NTS, consists of 90 sampling locations (figures 1 and 2) where NERC-LV personnel collect 1-gallon water samples from wells, open and closed springs, lakes, and ponds on a monthly or quarterly basis. In the event of a release of radioactivity from the NTS, special sampling within the affected area



CAL-NEV JET FUELS
SLOAN RD
FREEWAY
CRAIG RD
CRAIG RN
WELL #28
GOWAN RD
JAY
FRANCIS RESIDENCE
CHEYENNE AVE
TORREY PINES DR
JONES BLVD
DECATUR BLVD
PECOS RD
MADRE MESA DR
CUNNINGHAM RN
SMOKE RANCH RD
RAINBOW BLVD
LAS VEGAS BLVD
LAMB BLVD
NELLIS BLVD
ALLEN
LAKE MEAD BLVD
LLOYD RN
OWENS AVE
VEGAS DR
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
25th ST
MAIN ST
CHARLESTON BLVD
RANCHO RD
OAKEY BLVD
WYO AVE
SAHARA AVE
SPRING MTN RD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
DESERT INN RD
FLAMINGO RD
LDS DAIRY FARM
MONSON RD
LAB II WELL
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
TOMIYASU LN
VEGAS ESTATES
HENDERSON CUTOFF
SAMPLING LOCATION AND MAP NUMBER

Figure 2. Water Surveillance Network, Las Vegas Valley

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Table 1. Analytical procedures

Type of analysis	Analytical equipment	Counting period (min.)	Analytical procedures	Sample size (liter)	Detection limits (pCi/liter)
Gamma[a]	Gamma spectrometer with a 10 by 10 cm NaI(Tl) crystal with input to 200 channels (0–2 MeV) of 400-channel pulse-height analyzer	10–40	Radionuclide concentrations quantitated from gamma spectrometer data by computer using an eight element matrix technique	3.5	Generally 10 pCi/liter for most common fallout radionuclides in a simple spectrum.
Tritium	Automatic liquid scintillation counter with output printer	100	Sample prepared by distillation and counted in scintillation counter	.005	[b], [c] ≈320
Strontium-89, -90	Low background, thin-window, gas flow proportional counter with a 5.7 cm diameter window (80 $\mu g/cm^2$)	50	Chemical separation by ion exchange. Separated sample counted successively; activity calculated by solution of simultaneous equations	1.0	[b] Strontium-89 = 5 [b] Strontium-90 = 2
Radium-226	Alpha scintillation counter	30	Chemical separation of radium, dissolve, and radon emanation procedure	1.5	[b] ≈.1
Gross alpha[d] Gross beta[d]	Low background, thin-window gas flow proportional counter with a 5.7 cm diameter window (80 $\mu g/cm^2$)	50	Sample evaporated, residue counted	.2	[b] alpha = 2 [b] beta = 2

[a] On total liquid sample.

[b] The detection limit for a given sample is defined as that concentration which is equal to the 2-sigma counting error.

[c] The detection limit for samples analyzed during February and thereafter was ≈220 pCi/liter.

[d] On total solids of samples.

is conducted to determine radionuclide concentrations and to take protective action, if required.

Sampling in support of operations such as Project Rulison and the Cannikin Event is generally conducted in the same manner. Since the major sampling efforts for these projects were completed last year, only a few water samples are now being collected at selected locations on a reduced frequency. A description of the sampling programs and analytical results for these projects prior to January 1972 are reported separately (*1-3*).

Analytical procedures

All samples are analyzed by gamma spectroscopy and counted for gross alpha and gross beta radioactivity. In addition, samples from approximately 24 locations west, south, and southeast of NTS are routinely analyzed for tritium. Further analyses (strontium-89, -90, plutonium-238, -239, uranium, or tritium) on special samples are dependent upon whether activity related to the NTS is detected by gamma spectroscopy and/or special requirements of the sampling program.

Table 1 lists the general analytical procedures and detection limits, as described by Johns (*4*) and Lem and Snelling (*5*). For gamma spectroscopy analysis, the samples are placed in 3.5-liter inverted-well Marinelli beakers. All routine samples are counted 40 minutes. Special samples collected following known releases of activity are normally counted for 20 minutes, but this may vary from 10 to 40 minutes, depending upon radionuclide concentrations and total sample workload. The activity concentration of each of the detected nuclides at time of count is calculated and extrapolated to time of collection.

Results

The analytical results of all water samples collected in January, February, and March 1972 by NERC-LV surveillance programs are listed in table 2. Two samples each were collected in Alaska and Colorado in support of

Table 2. NERC-LV water surveillance results, January–March 1972

Location	Map	Date collected (1972)	Radioactivity concentration[a] (pCi/liter)			
			Sample type[b]	Gross alpha	Gross beta	Tritium
Alaska:						
Kodiak						
Dispensary		1/10	24	<1	6 ±33	<310
St. Paul:						
Kitchen tap		1/4	24	<3	<3	510 ±320
California:						
Bishop:						
Fish & Game Office	9	1/6	23	<2	4 ±3	NA
		2/10	23	<1	<3	NA
		3/6	23	<2	3 ±3	NA
Bishop:						
Owens River, 3 miles east	10	1/6	22	6 ±4	3 ±3	NA
		2/10	22	8 ±4	6 ±3	NA
		3/6	22	6 ±4	9 ±3	NA
Death Valley Jct:						
Lila's Cafe	21	1/5	23	<7	12 ±4	<320
		2/10	23	8 ±6	11 ±4	<260
		3/7	23	10 ±6	7 ±4	260 ±190
Furnace Creek:						
Visitors Center	29	1/6	27	<5	12 ±4	NA
		2/9	27	<4	11 ±4	NA
		3/7	27	<5	8 ±4	NA
Furnace Creek:						
Pond	28	1/6	21	6 ±5	11 ±4	NA
		2/9	21	<4	13 ±4	NA
		3/7	21	<4	14 ±4	NA
Hinkley:						
Bill Nelson Dairy	39	1/5	23	27 ±1	17 ±4	NA
		2/8	23	8 ±5	6 ±4	NA
		3/7	23	11 ±6	9 ±4	NA
Little Lake:						
Little Lake Ranch	60	1/6	21	14 ±8	26 ±5	NA
		2/8	21	21 ±9	21 ±5	NA
		3/7	21	15 ±8	31 ±5	NA
Lone Pine:						
Diaz Lake	61	1/6	21	18 ±8	27 ±4	NA
		2/8	21	27 ±9	31 ±5	NA
		3/17	21	33 ±10	25 ±5	NA
Forest Service Ranger Station	62	1/6	23	<2	<3	NA
		2/8	23	<2	<3	NA
		3/7	23	6 ±3	<3	NA
Olancha:						
Haiwee Reservoir	73	1/6	21	4 ±3	8 ±3	NA
		2/8	21	3 ±3	4 ±3	NA
		3/7	21	7 ±4	8 ±3	NA
Ridgecrest:						
City Hall	76	1/6	23	<4	4 ±3	NA
		2/8	23	5 ±4	3 ±3	NA
		3/7	23	4 ±3	<3	NA
Shoshone:						
Chevron Service Station	79	1/4	23	7 ±6	22 ±4	NA
		2/10	23	<5	18 ±4	NA
		3/7	23	<6	17 ±4	NA
Colorado:						
Grand Valley:						
Battlement Creek		1/22	22	NA	NA	620 ±340
Grand Valley:						
Battlement Creek above Test Well		1/22	22	NA	NA	550 ±330
Nevada:						
Adaven:						
Canfield Ranch	1	1/10	22	5 ±3	5 ±3	NA
		2/9	22	5 ±4	<3	NA
		3/8	22	4 ±3	5 ±3	NA
Alamo:						
Sheri's Bar	2	1/10	23	4 ±4	5 ±3	NA
		2/8	23	<3	<3	NA
		3/7	23	6 ±4	3 ±3	NA
Pahranagat Lake	3	1/10	21	25 ±9	25 ±4	NA
		2/8	21	23 ±8	21 ±4	NA
		3/7	21	12 ±6	18 ±4	NA
Wright Dairy	4	1/10	23	<5	12 ±4	NA
		2/8	23	5 ±4	10 ±4	NA
		3/7	23	<4	10 ±4	NA
Ash Meadows:						
Ash Meadows Lodge	5	NS	23			
		2/9	23	6 ±5	17 ±4	<280
		3/7	23	10 ±6	12 ±4	<200
Ash Meadows Pond	6	NS	21			
		2/9	21	14 ±7	19 ±4	NA
		3/7	21	15 ±8	22 ±5	NA

See footnotes at end of table.

Table 2. NERC-LV water surveillance results, January–March 1972—continued

Location	Map	Date collected (1972)	Radioactivity concentration[a] (pCi/liter)			
			Sample type[b]	Gross alpha	Gross beta	Tritium
Nevada—(continued)						
Austin:						
County Courthouse	7	1/12	27	30 ±7	17 ±4	NA
		2/9	27	22 ±6	21 ±4	NA
		3/8	27	21 ±6	18 ±4	NA
Beatty:						
Richfield Service Station	8	1/6	23	10 ±6	12 ±4	<310
		2/10	23	15 ±8	11 ±4	<290
		3/8	23	8 ±6	7 ±4	<220
Blue Diamond:						
Post Office	11	1/4	23	<4	3 ±3	<320
		2/10	23	<4	<3	<280
		3/6	23	<3	<3	300 ±250
Blue Jay Highway:						
Maintenance Station	12	1/11	23	4 ±3	7 ±3	NA
		2/10	23	6 ±4	6 ±3	NA
		3/8	23	<4	6 ±3	NA
Cactus Springs:						
Mobil Service Station	13	1/6	27	4 ±3	3 ±3	<320
		2/8	27	3 ±1	4 ±1	<310
		3/9	27	<2	<3	<220
Caliente:						
Agricultural Extension Station	14	1/11	23	7 ±4	7 ±3	NA
		2/10	23	5 ±4	6 ±3	NA
		3/8	23	6 ±4	4 ±3	NA
Meadow Valley wash	15	1/11	22	9 ±6	14 ±4	NA
		2/10	22	5 ±5	15 ±4	NA
		3/8	22	14 ±7	14 ±4	NA
Clark Station:						
Five Mile Ranch	17	NS	27			
		2/10	27	<3	6 ±3	NA
		3/9	27	<4	9 ±4	NA
Coyote Summit:						
Sand Spring well	18	NS	23			
		2/8	23	5 ±3	5 ±3	NA
		3/8	23	31 ±10	20 ±4	NA
Currant:						
Currant Pond	19	1/13	21	12 ±6	5 ±3	NA
		2/8	21	13 ±5	8 ±1	NA
		3/9	21	5 ±5	6 ±3	NA
Currant Ranch Cafe	20	1/13	27	10 ±5	9 ±4	NA
		2/8	27	14 ±6	10 ±4	NA
		3/8	27	8 ±5	5 ±3	NA
Diablo Highway:						
Maintenance Station	22	1/10	23	5 ±3	7 ±3	NA
		2/8	23	<3	7 ±3	NA
		3/7	23	<4	9 ±4	NA
Diablo:						
Reed Ranch	23	1/10	21	26 ±7	18 ±4	NA
		2/8	21	29 ±9	17 ±4	NA
		3/7	21	18 ±7	24 ±4	NA
Elgin:						
Water tower	24	1/12	23	5 ±5	9 ±3	NA
		2/9	23	9 ±5	11 ±4	NA
		NS	23			
Ely:						
Chevron Service Station	25	1/11	24	5 ±3	<3	NA
		2/9	24	4 ±3	<3	NA
		3/7	24	3 ±3	<3	NA
Comins Lake	26	NS	21			
		NS	21			
		3/7	21	3 ±3	5 ±3	NA
Eureka:						
Chevron Service Station	27	1/12	24	5 ±4	4 ±3	NA
		2/9	24	<3	3 ±3	NA
		3/8	24	5 ±3	5 ±3	NA
Glendale:						
Chevron Service Station	32	1/10	27	<5	11 ±4	NA
		2/8	27	9 ±6	13 ±4	NA
		3/7	27	7 ±5	10 ±4	NA
Muddy River	33	1/10	22	<6	16 ±4	NA
		2/8	22	7 ±6	13 ±4	NA
		3/7	22	5 ±5	14 ±4	NA
Goldfield:						
Alkali Springs	34	1/11	21	<8	26 ±5	NA
		2/8	21	<6	19 ±4	NA
		3/7	21	<7	24 ±5	NA
Chevron Service Station	35	1/10	23	<4	<3	NA
		2/8	23	5 ±4	3 ±3	NA
		3/7	23	<4	<3	NA
Hawthrone:						
Walker Lake[c]	36	NS	21			
		NS	21			
		3/7	21		130 ±21	NA

See footnotes at end of table.

Table 2. NERC-LV water surveillance results, January–March 1972—continued

Location	Map	Date collected (1972)	Radioactivity concentration[a] (pCi/liter)			
			Sample type[b]	Gross alpha	Gross beta	Tritium
Nevada—(continued)						
Hiko:						
Crystal Springs	37	1/10	27	7 ±4	8 ±3	NA
		2/8	27	8 ±4	6 ±4	NA
		3/7	27	14 ±5	10 ±7	NA
Schofield Dairy	38	1/10	23	23 ±8	30 ±5	NA
		2/8	23	24 ±8	37 ±5	NA
		3/7	23	38 ±10	21 ±4	NA
Indian Springs:						
Chevron Service Station	40	1/6	23	5 ±4	<3	<310
		2/8	23	5 ±3	<3	<280
		3/9	23	2 ±2	<3	<220
Las Vegas:						
Cal-Nev Jet Fuels	41	1/3	23	4 ±3	6 ±3	<290
		2/15	23	<3	4 ±3	230
		NS	23			
Craig Ranch golf course	42	1/3	23	5 ±3	10 ±4	<290
		2/15	23	10 ±5	5 ±3	<230
		NS	23			
Cunningham Ranch	43	1/3	23	<3	<3	<290
		2/15	23	<3	<3	<210
		NS	23			
Desert Game Range	44	1/6	23	6 ±4	7 ±3	<310
		2/8	23	15 ±5	4 ±3	<310
		3/9	23	22 ±6	14 ±4	400 ±250
Desert Game Range Pond	45	1/6	21	<3	4 ±3	<310
		2/8	21	5 ±3	3 ±3	<280
		3/9	21	4 ±3	<3	<200
Francis residence	46	1/3	23	<5	5 ±3	<290
		2/15	23	6 ±5	<3	<190
		NS	23			
Lab II, NERC-LV	47	1/3	24	6 ±5	7 ±3	1100 ±310
		2/15	24	<5	5 ±4	870 ±240
		NS	24			
Lake Mead, Vegas Wash	48	1/3	21	<5	9 ±4	1400 ±310
		2/15	21	<5	7 ±4	760 ±220
		NS	21			
LDS dairy farm	49	1/4	23	<7	12 ±4	<280
		2/16	23	<8	18 ±5	<210
		NS	23			
Las Vegas:						
Lloyd Ranch	50	1/3	23	6 ±5	6 ±3	360 ±290
		2/15	23	<5	7 ±4	<190
		NS	23			
L V Water District well 28	51	1/3	23	4 ±3	4 ±3	<290
		2/15	23	4 ±3	<3	<230
		NS	23			
Municipal golf course	52	1/3	23	4 ±3	4 ±3	<290
		2/15	23	<3	<3	<230
		NS	23			
Tule Springs	53	1/6	23	10 ±4	9 ±3	<340
		2/8	23	6 ±3	<3	<290
		3/9	23	3 ±2	<3	<250
Tule Springs Pond	54	1/6	21	4 ±3	6 ±3	NA
		2/8	21	10 ±4	6 ±3	NA
		3/9	21	6 ±3	4 ±3	NA
Vegas Estates	55	1/3	23	<6	13 ±4	<290
		2/16	23	<6	12 ±4	<210
		NS	23			
Lathrop Wells:						
Texaco Service Station	56	1/5	23	<4	4 ±3	<320
		2/8	23	7 ±4	12 ±4	290
		3/8	23	4 ±3	5 ±3	230 ±220
Lida Junction:						
Cottontail Ranch	57	NS	23			
		2/8	23	17 ±7	13 ±4	NA
		3/6	23	9 ±6	16 ±4	NA
Lida:						
Lida Livestock Company	58	1/10	27	4 ±3	<3	NA
		2/8	27	<3	<3	NA
		3/16	27	<3	<3	NA
Pond at storage tank	59	1/10	21	3 ±3	<3	NA
		2/8	21	<3	3 ±3	NA
		3/6	21	5 ±4	6 ±3	NA
Lund:						
Gardner grocery	63	1/11	23	6 ±3	10 ±4	NA
		2/9	23	5 ±3	<3	NA
		3/9	23	5 ±3	<3	NA
Manhattan:						
Country store	64	1/12	27	26 ±8	9 ±4	NA
		2/9	27	16 ±7	10 ±4	NA
		3/8	27	20 ±7	6 ±3	NA
Seyler Reservoir	65	1/12	21	8 ±5	13 ±4	NA
		2/9	21	<3	6 ±3	NA
		3/8	21	22 ±8	36 ±5	NA

See footnote at end of table.

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Table 2. NERC-LV water surveillance results, January–March 1972—continued

Location	Map	Date collected (1972)	Radioactivity concentration[a] (pCi/liter)			
			Sample type[b]	Gross alpha	Gross beta	Tritium
Nevada—(continued)						
Mercury:						
Groom Lake	66	1/10	23	4 ±3	7 ±3	NA
		2/8	23	4 ±3	<4	NA
		3/7	23	<4	6 ±3	NA
Moapa:						
Pedersen Valley View Ranch	67	1/10	27	6 ±5	13 ±4	NA
		2/8	27	7 ±5	10 ±4	NA
		3/7	27	6 ±4	7 ±3	NA
Mt. Charleston:						
Kyle Canyon	68	NS	27			
		2/8	27	<2	<3	320 ±310
		3/9	27	<2	<3	380 ±220
Kyle Canyon Pond	69	NS	21			
		NS	21			
		NS	21			
Nyala:						
Sharp's Ranch	72	1/11	23	4 ±3	<3	NA
		2/10	23	3 ±3	<3	NA
		3/8	23	<3	4 ±3	NA
Pahrump:						
Texaco Service Station	74	1/4	23	5 ±4	5 ±3	NA
		2/10	23	<3	<3	NA
		3/6	23	4 ±3	<3	NA
Pioche:						
Country Courthouse	75	1/11	24	3 ±3	11 ±4	NA
		2/9	24	4 ±3	4 ±4	NA
		3/8	24	3 ±3	7 ±3	NA
Round Mt:						
Mobil Service Station	77	1/12	27	<3	4 ±3	NA
		2/9	27	3 ±2	4 ±3	NA
		3/8	27	3 ±2	<3	NA
Scotty's Junction:						
Chevron Service Station	78	1/13	23	<6	12 ±4	<290
		2/8	23	<5	13 ±4	<250
		3/6	23	<4	10 ±4	<200
Springdale:						
Peacock Ranch	80	1/5	27	<5	11 ±4	<310
		2/10	27	<4	11 ±4	<280
		3/8	27	<4	7 ±3	<220
Pond	81	1/5	21	<6	13 ±4	NA
		2/10	21	5 ±5	13 ±4	NA
		3/8	21	4 ±4	12 ±4	NA
Sunnyside:						
Adam McGill Reservoir	83	1/11	21	7 ±5	8 ±3	NA
		2/9	21	15 ±6	8 ±4	NA
		3/9	21	7 ±4	8 ±3	NA
Wildlife Mgt Headquarters	84	1/11	27	<3	<3	NA
		2/9	27	3 ±2	5 ±3	NA
		3/8	27	<3	4 ±3	NA
Tonopah:						
Jerry's Chevron Station	85	1/11	23	<3	5 ±3	NA
		2/8	23	<3	7 ±4	NA
		3/8	23	4 ±3	7 ±3	NA
Tonopah Test Range CP-1	86	1/11	23	10 ±5	10 ±4	NA
		2/10	23	6 ±5	5 ±3	NA
		3/9	23	6 ±4	5 ±3	NA
Warm Springs:						
Fallini's Pond	87	NS	21			NA
		2/8	21	20 ±9	48 ±6	NA
		3/7	21	12 ±8	43 ±5	NA
Hot Creek Ranch	88	1/12	27	6 ±5	16 ±4	NA
		2/8	27	<5	10 ±4	NA
		3/8	27	<6	12 ±4	NA
Service station and Cafe	89	NS	27			NA
		NS	27			
		3/9	27	11 ±7	21 ±4	NA
Twin Springs Ranch	90	1/11	23	13 ±6	16 ±4	NA
		2/10	23	5 ±4	9 ±4	NA
		3/8	23	6 ±5	10 ±4	NA
Utah:						
Cedar City:						
M. D. Baldwin Reservoir	16	1/11	24	<3	<3	NA
		2/8	24	<3	<3	NA
		3/14	24	<3	3 ±3	NA
Garrison:						
Pruess Reservoir[c]	30	NS	21			
		NS	21			
		3/7	21	15 ±7	14 ±4	NA
Rowley grocery	31	1/12	23	3 ±3	4 ±3	NA
		2/10	23	4 ±3	<3	NA
		3/7	23	<4	<3	NA

See footnotes at end of table.

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Table 2. NERC-LV water surveillance results, January–March 1972—continued

Location	Map	Date collected (1972)	Radioactivity concentration[a] (pCi/liter)			
			Sample type[b]	Gross alpha	Gross beta	Tritium
Utah—(continued						
Newcastle:						
Newcastle dairy	71	1/11	24	3 ±2	4 ±3	NA
		2/9	24	7 ±5	8 ±4	NA
		3/15	24	<5	8 ±3	NA
Municipal Reservoir	70	1/11	21	<3	<3	NA
		2/9	21	4 ±3	8 ±4	NA
		3/14	21	10 ±6	10 ±4	NA
St. George:						
R. Cox dairy	82	1/10	24	8 ±5	8 ±3	NA
		2/8	24	4 ±2	<3	NA
		3/14	24	<3	4 ±3	NA

[a] Two-sigma counting error provided when available.
[b] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well
24—Multiple supply—mixed water sample consisting of mixed or multiple sources of water, such as well or spring.
27—Spring
[c] Quarterly samples.
NA, not analysed.
NS, no sample

the Cannikin Event and Project Rulison, respectively. All other samples listed in table 2 were collected from the Water Surveillance Network. No gamma-emitting fission products were detected in any of the samples.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

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(1) PAYNE, D. W. and R. F. GROSSMAN. Off-site radiological safety program for Project Rulison, re-entry portion of Phase III, NERC-LV-539-14. National Environmental Research Center, Las Vegas, Nev. (November 1972).

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(3) FORT, C. W. and D. T. WRUBLE. Final report of off-site radiological safety for the Cannikin Event, November 6, 1971, NERC-LV-539-2 (to be published).

(4) JOHNS, F. B. Southwestern Radiological Health Laboratory Handbook of radiochemical analytical methods, SWRHL-11. Southwestern Radiological Health Laboratory, Las Vegas, Nev. (March 1970).

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January–December 1970	December 1971
Mexican Air Monitoring Program	January–April 1972	September 1972
Plutonium in Airborne Particulates	October–December 1971	July 1972
Surface Air Sampling Program; 80th Meridian Network, *HASL*	January–December 1969	February 1972

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1. Radiation Alert Network
August 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during August 1972.

All other field techniques reported were within normal limits for the reporting station.

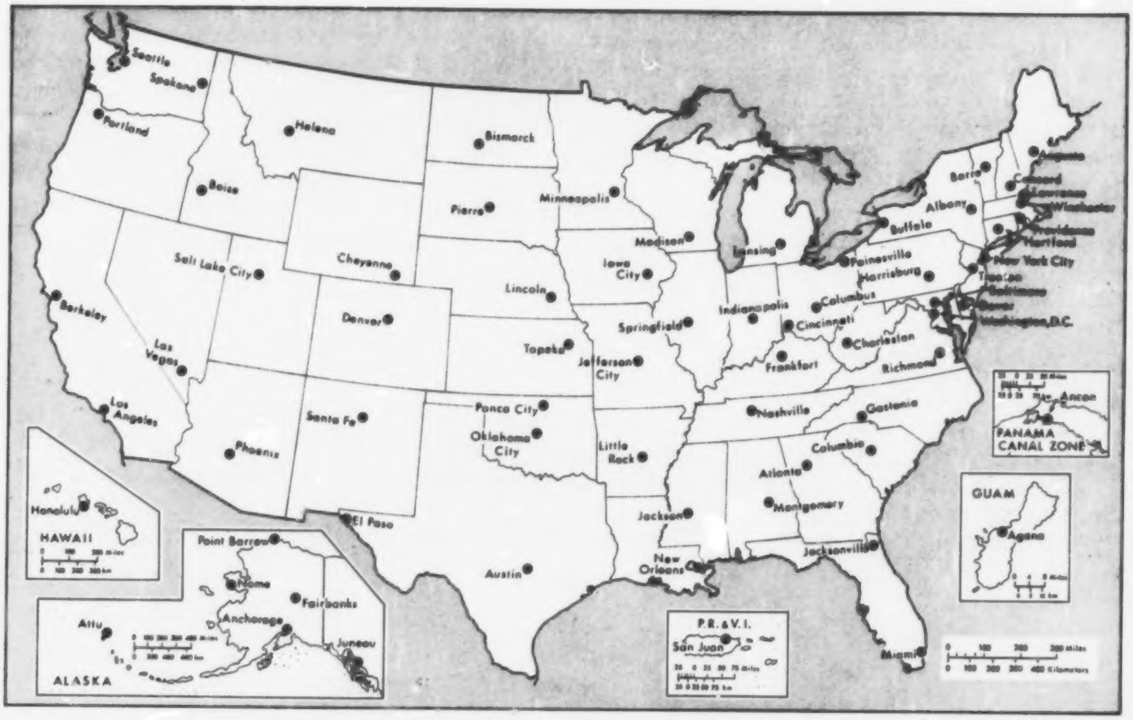
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Painesville
Harrisburg
Salt Lake City
Cheyenne
Iowa City
Lincoln
Denver
Berkeley
Indianapolis
Columbus
Springfield
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Jacksonville
New Orleans
Austin
Miami
Anchorage
Fairbanks
Nome
Point Barrow
Juneau
Attu
ALASKA
Honolulu
HAWAII
P.R. & V.I.
San Juan
GUAM
Agana
Ancon
PANAMA CANAL ZONE
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, August 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
			Maximum	Minimum	Average[a]	Number of samples	Total depth (mm)	Field estimation of deposition		
								Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	16	2	1	1	1	16	1	16	2
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	30	1	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	16	6	1	3	0				
Ark:	Little Rock	16	3	0	1	0				
Calif:	Berkeley	17	0	0	0	0				
	Los Angeles	13	2	0	1	0				
C.Z:	Ancon	15	0	0	0	0				
Colo:	Denver	13	6	1	2	3	83	(b)		
Conn:	Hartford	16	1	0	1	4	31	4	31	0
Del:	Dover	12	1	0	1	0				
D.C:	Washington	17	1	0	0	0				
Fla:	Jacksonville	15	1	0	0	8	143	7	116	2
	Miami	0				0				
Ga:	Atlanta	23	4	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	1	10	(b)		
Idaho:	Boise	19	2	0	1	0				
Ill:	Springfield	6	2	1	1	0				
Ind:	Indianapolis	16	2	0	1	0				
Iowa:	Iowa City	14	3	0	1	6	164	6	164	2
Kans:	Topeka	17	6	1	2	6	79	5	77	7
Ky:	Frankfort	0				0				
La:	New Orleans	13	0	0	0	5	27	(b)		
Maine:	Augusta	12	2	0	1	3	36	3	36	0
Md:	Baltimore	15	2	0	1	4	26	4	26	19
Mass:	Lawrence	15	1	0	1	2	39	2	39	0
	Winchester	12	3	0	1	2	20	2	20	0
Mich:	Lansing	16	1	0	0	10	86	10	86	12
Minn:	Minneapolis	15	2	0	1	5	50	5	50	7
Miss:	Jackson	12	3	0	1	1	15	1	15	0
Mo:	Jefferson City	15	5	0	2	6	35	6	35	0
Mont:	Helena	16	3	1	1	3	23	3	23	0
Nebr:	Lincoln	12	8	0	3	2	69	2	69	14
Nev:	Las Vegas	16	3	1	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	17	2	0	1	2	46	2	46	2
N. Mex:	Santa Fe	12	2	0	1	1	21	1	21	0
N.Y:	Albany	0				0				
	Buffalo	21	1	0	1	0				
	New York City	0				0				
N.C:	Gastonia	14	10	1	4	0				
N. Dak:	Bismarck	19	4	0	2	5	37	5	37	12
Ohio:	Cincinnati	0				0				
	Columbus	3	1	0	1	0				
	Painesville	11	1	0	1	4	41	4	41	8
Okla:	Oklahoma City	10	6	0	2	0				
	Ponca City	16	7	1	2	8	83	8	83	0
Oreg:	Portland	13	1	0	0	0				
Pa:	Harrisburg	7	2	0	1	1	20	1	20	4
P.R:	San Juan	0				0				
R.I:	Providence	16	2	0	1	0				
S.C:	Columbia	14	2	0	1	3	94	3	94	0
S. Dak:	Pierre	16	5	2	3	0				
Tenn:	Nashville	18	2	0	1	5	107	5	107	2
Tex:	Austin	17	4	1	3	2	28	(b)		
	El Paso	16	4	0	1	0				
Utah:	Salt Lake City	19	2	1	1	0				
Vt:	Barre	16	5	1	2	6	38	6	38	5
Va:	Richmond	9	1	0	0	0				
Wash:	Seattle	5	0	0	0	1	6	(b)		
	Spokane	18	2	0	1	0				
W. Va:	Charleston	15	3	0	1	4	49	4	49	6
Wisc:	Madison	14	2	0	0	4	100	4	100	3
Wyo:	Cheyenne	15	10	2	5	0				
Network summary		831	10	0	1	118	62	4	55	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] August 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for August 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, August 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.1	0.0	0.1	22	1.3
Coral Harbour	4	.0	.0	.0	56	.1
Edmonton	4	.1	.1	.1	43	3.0
Ft. Churchill	3	.1	.0	.0	30	2.7
Fredericton	4	.0	.0	.0	23	2.2
Goose Bay	4	.0	.0	.0	17	2.3
Halifax	9	.1	.0	.1	26	1.9
Inuvik	4	.0	.0	.0	37	2.0
Montreal	4	.1	.0	.0	19	2.4
Moosonee	4	.1	.0	.1	23	1.8
Ottawa	4	.1	.0	.1	25	3.5
Quebec	4	.1	.0	.1	18	3.2
Regina	4	.1	.0	.1	26	1.1
Resolute	4	.0	.0	.0	16	.4
St. John's, Nfld	4	.0	.0	.0	11	1.3
Saskatoon	4	.1	.0	.1	50	1.6
Sault Ste. Marie	NS				50	4.9
Thunder Bay	4	.1	.1	.1	51	2.1
Toronto	4	.0	.0	.0	21	2.6
Vancouver	4	.0	.0	.0	51	1.2
Whitehorse	4	.1	.0	.0	41	1.8
Windsor	4	.1	.0	.1	23	3.0
Winnipeg	4	.1	.0	.0	15	1.6
Yellowknife	4	.0	.0	.0	44	1.4
Network summary	96	0.1	0.0	0.0	31	2.1

NS, no sample.

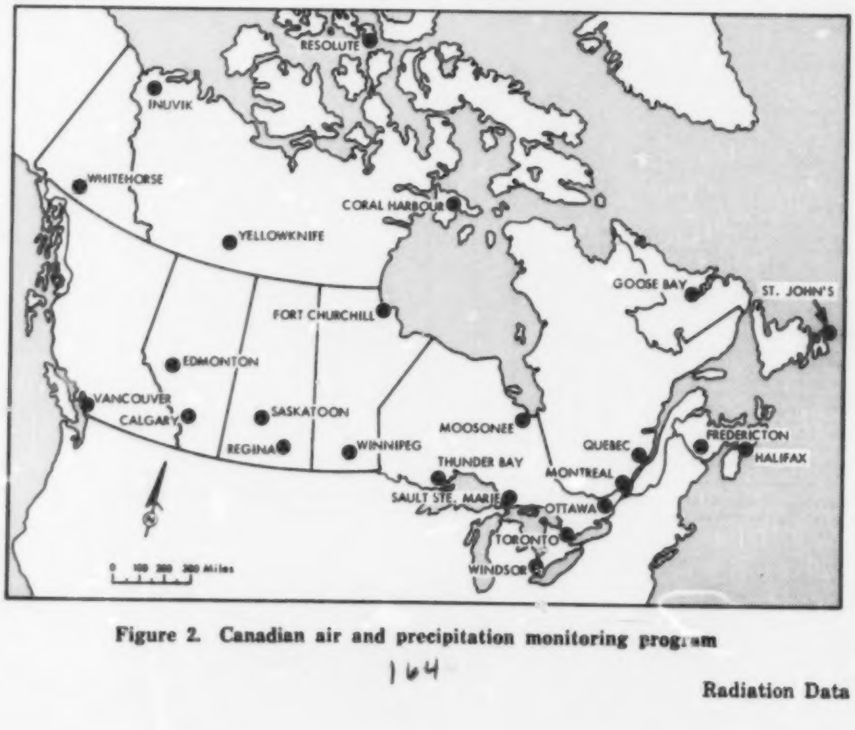
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program August 1972

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The August 1972 air monitoring results from the participating countries are given in table 3.

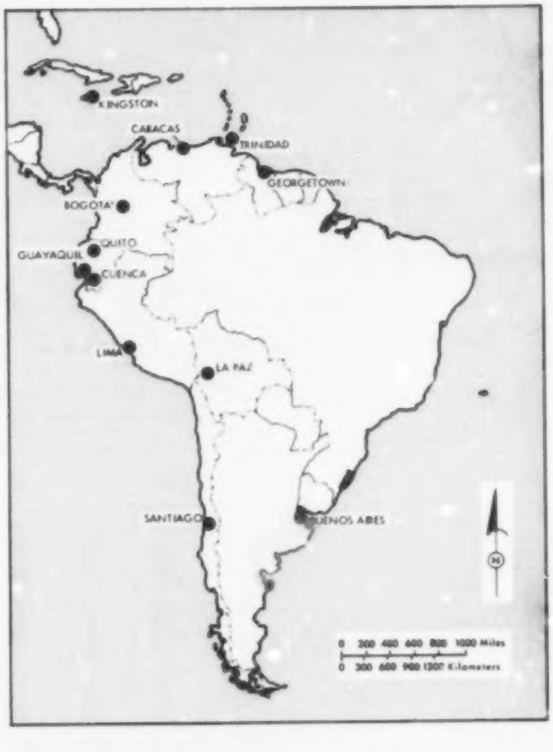

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, August 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Burenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	30	1.43	0.02	0.18
Colombia:	Bogota	12	0.05	.00	.02
Ecuador:	Cuenca	0			
	Guayaquil	21	3.90	.03	.45
	Quito	21	.05	.00	.01
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	8	.03	.01	.02
West Indies:	Trinidad	0			
Pan American summary		92	3.90	0.00	0.17

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program August 1972

Bureau of Radiological Health California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

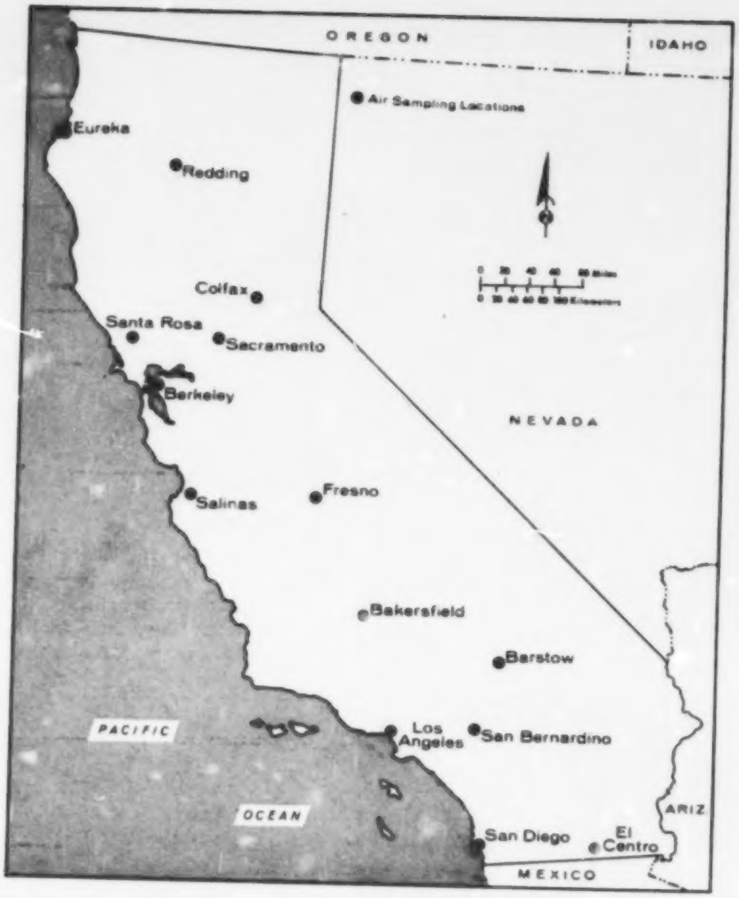
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 4. California air sampling program stations

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2-cubic feet per minute capacity, or 81.5 cubic meters per day. All volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for August 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air August 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	31	0.99	0.09	0.30
Barstow	31	.74	.09	.25
Berkeley	31	.12	.00	.06
Colfax	31	.33	.03	.19
El Centro	31	2.15	.03	.28
Eureka	31	.14	.00	.05
Fresno	31	1.73	.05	.25
Los Angeles	31	.29	.07	.13
Redding	30	1.02	.08	.28
Sacramento	31	.62	.05	.18
Salinas	31	1.36	.09	.25
San Bernardino	29	.96	.11	.27
San Diego	31	.35	.08	.13
Santa Rosa	28	.26	.00	.10
Summary	428	2.15	0.00	0.19

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5. Plutonium in Airborne Particulates January–March 1972

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Division of Atmospheric Surveillance, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965, and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Eastern Environmental Radiation Laboratory, Montgomery, Ala. The laboratory analyzes a composite of these samples from each station on a quarterly basis. The results from January–March 1972 are presented in table 5. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 5. Plutonium in airborne particulates January–March 1972

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	Plutonium-239/ plutonium-238
Alaska:	Anchorage	5 ±3	27 ±11	5 ±4
Ariz:	Phoenix	12 ±4	61 ±15	5 ±2
Colo:	Denver	15 ±5	61 ±16	4 ±2
Hawaii:	Honolulu	2 ±1	19 ±4	10 ±5
La:	New Orleans	2 ±1	30 ±7	15 ±8
Md:	Baltimore	5 ±2	21 ±6	4 ±2
N.Y:	Buffalo	2 ±1	18 ±5	9 ±5
N.C:	Gastonia	3 ±2	38 ±11	13 ±9
S. Dak:	Pierre	3 ±1	21 ±5	7 ±3
Tex:	Austin	3 ±1	38 ±8	12 ±5
Wash:	Seattle	4 ±2	19 ±4	4 ±3

Other coverage in *Radiation Data and Reports:*

Period	Issue
January–March 1971	November 1971
April–June 1971	March 1972
July–September 1971	April 1972
October–December 1971	July 1972

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

Air Surveillance Network, August 1972

National Environmental Research Center—Las Vegas,[1] *Environmental Protection Agency*

The Air Surveillance Network (ASN), operated by the National Environmental Research Center (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station which lies within the NTS, and by the AEC at any other designated testing sites.[2]

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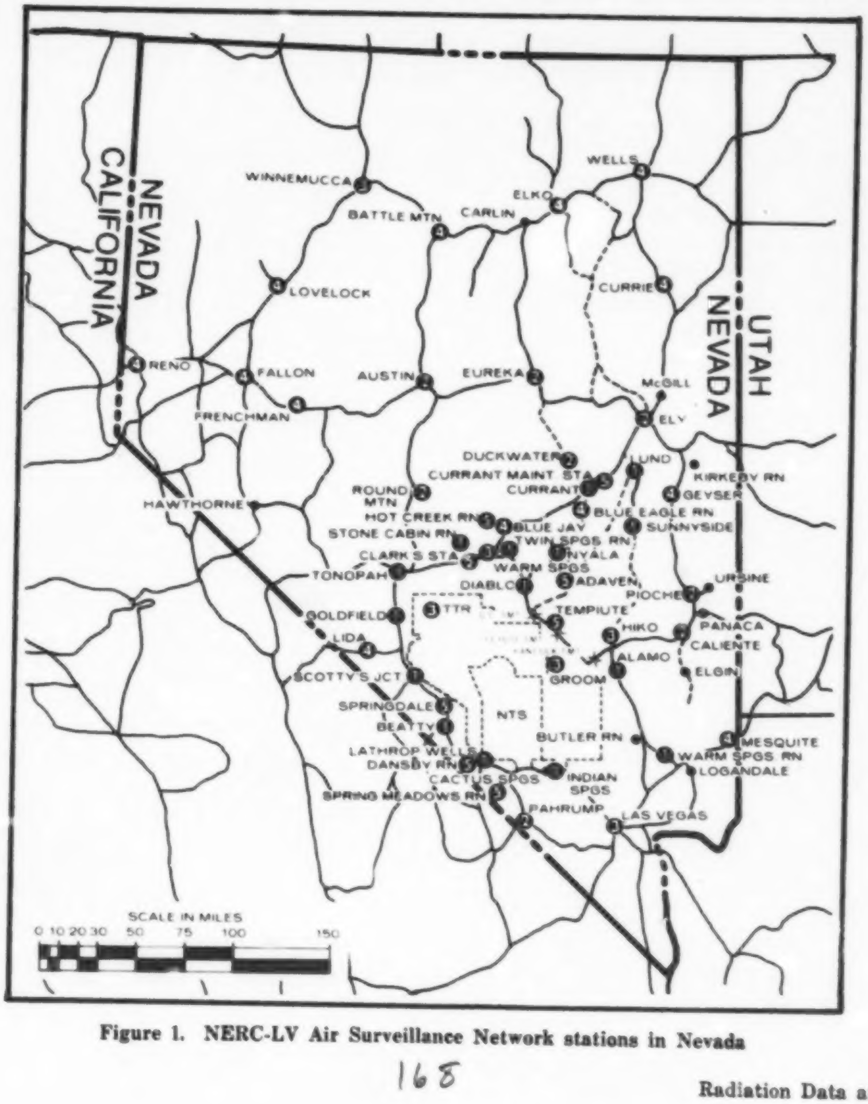
[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.


NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
LOVELOCK
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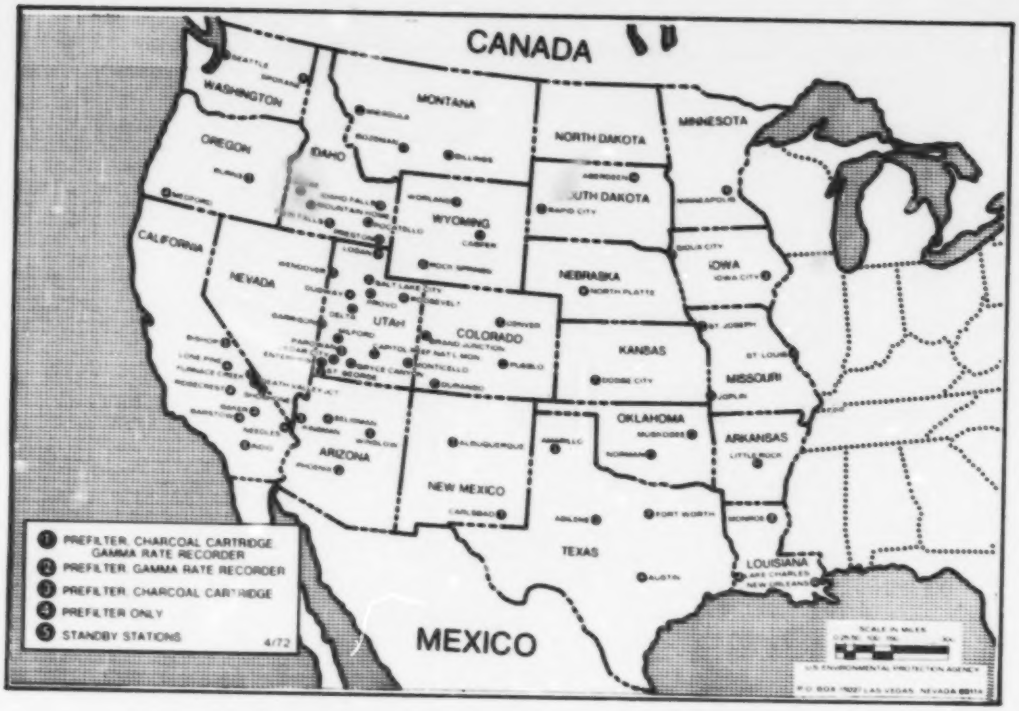
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT. STA.
CURRANT
KIRKEBY RN
GEYSER
ROUND MTN
HAWTHORNE
HOT CREEK RN
BLUE JAY
BLUE EAGLE RN
SUNNYSIDE
STONE CABIN RN
TWIN SPGS RN
NYALA
CLARK S STA
WARM SPGS
ADAVEN
TONOPAH
DIABLO
URSINE
PIOCHE
TTR
TEMPIUTE
GOLDFIELD
HIKO
PANACA
CALIENTE
LIDA
ALAMO
GROOM
ELGIN
SCOTTY'S JCT
SPRINGDALE
BEATTY
NTS
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEADOWS RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV Air Surveillance Network stations in Nevada


CANADA
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OREGON
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WYOMING
UTAH
COLORADO
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NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
SALT LAKE CITY
DENVER
ALBUQUERQUE
NEW ORLEANS
① PREFILTER, CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER, GAMMA RATE RECORDER
③ PREFILTER, CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
4/72
SCALE IN MILES
U.S. ENVIRONMENTAL PROTECTION AGENCY
P.O. BOX 15027 LAS VEGAS, NEVADA 89114

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

The stations are operated by State health department personnel and by private individuals on a contract basis. Daily 24-hour samples are collected at each station. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

Copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates for each of the network stations. The minimum reported concentration for gross beta is 0.1 pCi/m^3; however, gross beta concentrations above the minimum detectable concentration of 0.06 pCi/m^3 are used in determining averages. Individual concentrations which are below the minimum detectable concentration are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reported level are reported as $<$0.1 pCi/m^3. The highest gross beta concentration within the network on a single filter during August was 1.3 pCi/m^3 at Monticello, Utah.

No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during August.

Complete copies of this summary and listings of the daily gross beta and gamma spcetrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 1. Summary of gross beta radioactivity concentrations in air, August 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	31	0.2	<0.1	0.1
	Phoenix	31	.2	<.1	.1
	Seligman	31	.2	<.1	.1
	Winslow	29	.2	<.1	.1
Ark:	Little Rock	23	.2	<.1	.1
Calif:	Baker	30	.2	<.1	.1
	Barstow	31	.2	<.1	.1
	Bishop	30	.2	<.1	.1
	Death Valley Junction	29	.3	<.1	.2
	Furnace Creek	31	.2	<.1	.1
	Indio	31	.3	<.1	.1
	Lone Pine	31	.7	<.1	.2
	Needles	21	.2	<.1	.1
	Ridgecrest	22	.2	<.1	.1
	Shoshone	28	.3	<.1	.1
Colo:	Denver	22	.7	<.1	.1
	Durango	31	.2	<.1	.1
Idaho:	Boise	31	.3	<.1	.2
	Idaho Falls	23	.4	<.1	.1
	Preston	30	.3	<.1	.1
	Twin Falls	31	.3	<.1	.1
Iowa:	Iowa City	23	.2	<.1	.1
	Sioux City	16	.2	<.1	.1
Kans:	Dodge City	31	.2	<.1	.1
La:	Lake Charles	21	.2	<.1	.1
	Monroe	24	.3	<.1	.1
	New Orleans	22	.2	<.1	.1
Minn:	Minneapolis	22	.2	<.1	.1
Mo:	Joplin	25	.2	<.1	.1
	St. Joseph	31	.5	<.1	.1
	St. Louis	31	.3	<.1	.1
Nebr:	North Platte	28	.2	<.1	.1
Nev:	Alamo	30	<.4	<.1	.1
	Austin	23	.2	<.1	.1
	Battle Mountain	31	.2	<.1	.1
	Beatty	31	.4	<.1	.1
	Blue Eagle Ranch (Currant)	28	.3	<.1	.1
	Blue Jay	31	.3	<.1	.1
	Caliente	30	.4	<.1	.1
	Currant Ranch	31	.3	<.1	.1
	Currie	31	.2	<.1	.1
	Diablo	31	.7	<.1	.1
	Duckwater	22	.3	<.1	.1
	Elko	31	.4	<.1	.2
	Ely	30	.2	<.1	.1
	Eureka	31	.3	<.1	.1
	Fallini's Twin Springs Ranch	17	.3	<.1	.2
	Fallon	31	.3	<.1	.2
	Frenchman station	31	.4	<.1	.2
	Geyser maintenance station	29	.7	<.1	.1
	Goldfield	30	.3	<.1	.1
	Groom Lake	30	.2	<.1	.1
	Hiko	31	.3	<.1	.1
	Indian Springs	26	.2	<.1	.1
Nev:	Las Vegas	22	.3	<.1	.1
	Lathrop Wells	30	.2	<.1	.1
	Lida	31	.3	<.1	.1
	Lovelock	31	.3	<.1	.2
	Lund	31	.2	<.1	.1
	Mesquite	31	.2	<.1	.1
	Nyala	31	.4	<.1	.2
	Pahrump	17	.2	<.1	.1
	Pioche	29	.3	<.1	.1
	Reno	31	.4	<.1	.1
	Round Mountain	31	.2	<.1	.1
	Scotty's Junction	27	.3	<.1	.1
	Stone Cabin Ranch	31	.2	<.1	.1
	Sunnyside	25	.3	<.1	.1
	Tonopah	31	.2	<.1	.1
	Tonopah Test Range	20	.2	<.1	.1
	Warm Springs	30	.2	<.1	.1
	Warm Springs Ranch	31	.2	<.1	.1
	Wells	31	.3	<.1	.1
	Winnemucca	31	.3	<.1	.2
N. Mex:	Albuquerque	22	.2	<.1	.1
	Carlsbad	29	.1	<.1	.1
Okla:	Muskogee	31	.2	<.1	.1
Oreg:	Burns	30	.5	<.1	.1
	Medford	30	.7	<.1	.1
S. Dak:	Aberdeen	31	.3	<.1	.1
	Rapid City	31	.3	<.1	.1
Tex:	Abilene	28	.2	<.1	.1
	Amarillo	31	.2	<.1	.1
	Austin	23	.2	<.1	.1
	Fort Worth	29	.3	<.1	.1

See footnote at end of table.

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Table 1. Summary of gross beta radioactivity concentrations in air, August 1972—continued

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average [a]
Utah:	Bryce Canyon	24	.2	<.1	.1
	Cedar City	28	1.2	<.1	.2
	Delta	29	.2	<.1	.1
	Dugway	31	.3	<.1	.1
	Enterprise	31	.3	<.1	.1
	Garrison	31	.3	<.1	.1
	Logan	30	1.0	<.1	.2
	Milford	30	.6	<.1	.1
	Monticello	3	1.3	.2	.4
	Parowan	27	.2	<.1	.1
	Provo	31	.5	<.1	.1
	Roosevelt	29	.3	<.1	.1
	Salt Lake City	31	.1	<.1	.1
	St. George	31	.3	<.1	.1
	Wendover	30	.3	<.1	.1
Wash:	Seattle	26	.2	<.1	.1
	Spokane	23	.3	<.1	.1
Wyo:	Rock Springs	31	.3	<.1	.1
	Worland	31	.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported as <0.1.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and enviromental monitoring around nuclear facilities.

Radiological Surveillance Around the Florida Power Corporation's Crystal River Power Reactor Site, 1971

Florida Division of Health

Since May 1969, radiological surveillance has been conducted around the Crystal River power reactor site of the Florida Power Corporation by the Florida Division of Health. Activities at this site include a 387 MW(e) coal-fired generating unit and a 510 MW(e) coal-fired generating unit with construction of unit three underway (this unit is to be an 855 MW(e) nuclear power generating plant). A description of the site and the sampling and analysis procedures used was presented in the September 1971 issue of *Radiological Health Data and Reports*. Sampling site locations are shown in figure 1.

Ninety-five samples of the environmental media shown in table 1 were collected.

During 1971, 95 air particulate samples were collected from five sampling locations (C 04, C 07, C 08, C 18, C 26). All levels of gross beta-gamma radioactivity were less than the minimum detectable level (1 pCi/m^3).

Table 2 presents the radioactivity found in samples of vegetation. The results of special vegetation samples and food crop samples are presented in table 3. The oranges were taken from a citrus grove located about 7.5 miles from the plant. Saw palmetto and its berries constitute an element in the diet of deer, and deer meat is in the direct human food chain.

Table 4 presents the radionuclide concentrations that were found in samples of marine biota. Concentrations of radioactivity found in

Table 1. Environmental samples collected at Crystal River, 1971

Vector	Number of samples collected in 1971				
	Jan–Mar	Apr–June	July–Sept	Oct–Dec	Total
Air particulates	5	29	22	40	95
Vegetation	29	30	30	32	121
Food crop	1	0	0	1	2
Milk	1	0	1	0	2
Soil	10	0	10	0	20
Silt	4	5	4	4	17
Marine biota	8	6	2	8	24
Seawater	6	5	7	5	23
Surface water	3	4	3	4	14
Drinking water	6	6	6	6	24
Precipitation	14	12	28	2	56
Thermoluminescent dosimeters	0	15	15	15	45

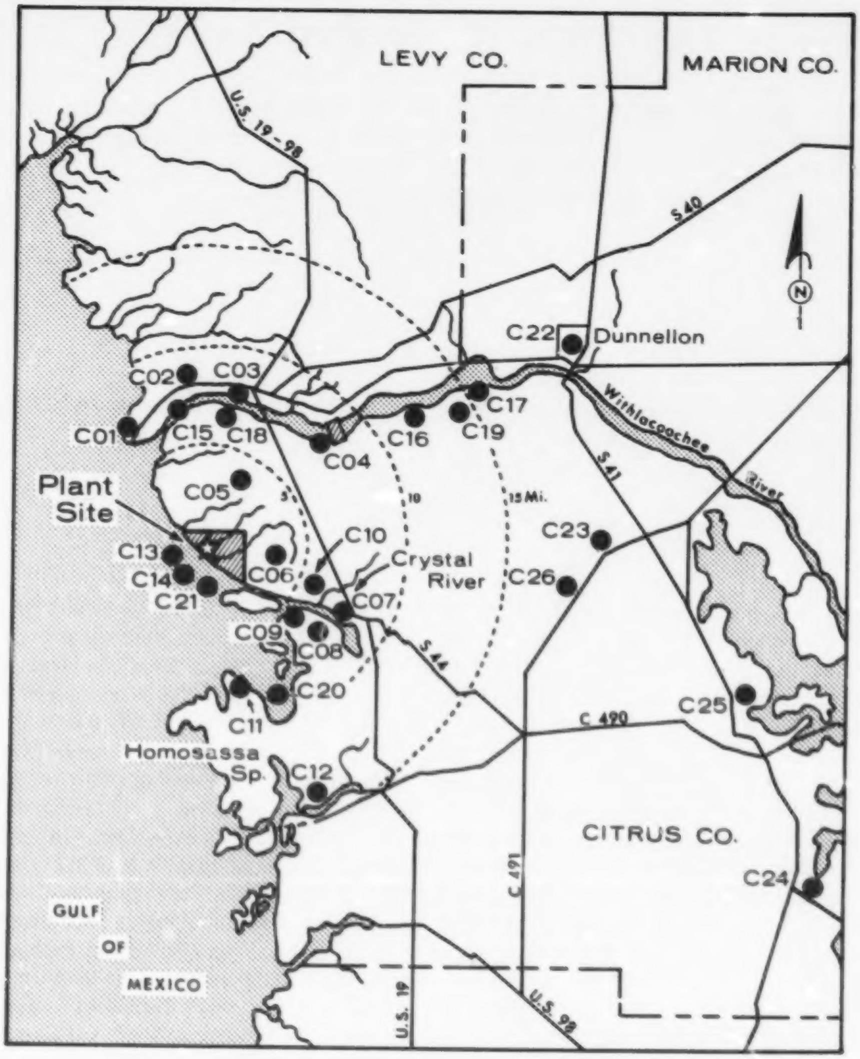
LEVY CO.
MARION CO.
U.S. 19-98
S 40
N
C22
Dunnellon
C02
C03
C01
C15
C18
C04
C16
C19
C17
Withlacoochee River
S 41
Plant Site
C05
5
10
15 Mi.
C23
C13
C14
C21
C06
C10
Crystal River
C07
C26
C09
C08
S 44
C20
C11
C25
C 490
Homosassa Sp.
C12
CITRUS CO.
C 491
C24
GULF OF MEXICO
U.S. 19
U.S. 98

Figure 1. Radiological sampling sites—Crystal River

samples of soil and silt are presented in table 5.

Samples of drinking water were taken from wells at locations C 07, C 10, C 18, C 22, C 23 and C 24 during February, May, August and November. These samples were analyzed for gross beta, gross alpha, tritium, and gamma-emitting radionuclides. The only concentration of radioactivity above the minimum detectable activity found in any of these samples was 6 pCi/liter of gross beta radioactivity in a sample taken from location C 07 in August.

Samples of surface water were taken from locations C 15, C 16, and C 17 in February, May, August, and November and from location

Table 2. Concentration of radionuclides in vegetation samples, Crystal River, 1971

Radionuclide and sampling sites	Radionuclide concentration (pCi/kg wet weight)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Gross beta:												
C 01	3,860	4,380	4,680	6,200	6,750	5,640	5,280	6,140	5,320	5,500	4,600	4,500
C 02	NS	4,450	4,340	7,510	5,650	5,950	6,300	4,670	4,130	5,200	NS	6,300
C 03	3,380	6,390	4,150	7,720	4,920	6,630	6,130	6,460	5,000	5,300	4,300	4,500
C 04	5,440	4,080	5,330	5,480	6,540	5,620	6,850	5,350	4,350	6,500	5,600	3,900
C 05	2,650	5,430	4,070	5,420	4,320	4,800	6,350	5,280	4,050	5,500	6,700	4,300
C 06	4,410	4,820	4,630	7,530	9,220	6,730	7,460	5,490	4,950	4,700	4,100	4,500
C 08	5,630	6,060	3,700	6,520	5,660	6,510	5,450	6,020	4,850	5,800	5,700	4,800
C 09	4,980	5,300	5,340	8,070	6,560	8,050	7,620	5,830	4,970	7,300	6,500	5,800
C 11	4,480	5,320	4,800	3,350	7,630	8,150	9,300	8,020	7,840	6,700	5,400	3,800
C 12	5,080	6,250	5,680	7,000	6,260	7,130	6,770	4,940	6,310	5,500	5,800	4,400
Gross alpha:												
C 01	(a)	497	414	589	943	774	616	(a)	(a)	(a)	(a)	420
C 02	NS	597	722	1,090	964	793	887	(a)	(a)	(a)	NS	(a)
C 03	(a)	733	371	947	651	944	592	(a)	(a)	(a)	(a)	(a)
C 04	207	270	604	898	894	766	942	(a)	(a)	(a)	(a)	300
C 05	(a)	379	599	1,040	681	464	816	(a)	(a)	(a)	(a)	430
C 06	430	291	570	1,040	1,570	1,200	856	(a)	(a)	(a)	(a)	(a)
C 08	398	684	411	788	643	640	825	(a)	(a)	(a)	(a)	(a)
C 09	478	734	447	1,090	825	939	868	(a)	(a)	(a)	(a)	(a)
C 11	537	582	560	671	1,110	847	1,320	(a)	(a)	(a)	(a)	(a)
C 12	604	842	580	1,020	741	583	836	(a)	(a)	(a)	(a)	(a)
Cesium-137:												
C 01	180	80	120	490	210	340	230	380	190	140	230	210
C 02	NS	70	70	1,700	4,100	2,900	850	200	760	780	NS	630
C 03	510	210	200	330	280	730	310	260	280	250	310	270
C 04	3,000	2,000	620	440	730	670	340	1,000	790	930	900	1,500
C 05	1,500	1,000	2,000	2,100	1,200	1,300	2,000	1,900	2,100	1,500	2,900	2,300
C 06	220	470	330	320	8,000	5,300	590	540	490	540	410	360
C 08	100	(a)	70	150	90	140	130	80	80	NS	70	NS
C 09	80	(a)	70	90	80	200	110	(a)	(a)	140	100	130
C 11	160	150	120	1,200	100	120	5,100	210	[b]6,800	160	190	170
C 12	90	60	140	260	270	180	160	500	230	400	390	410
Potassium-40:												
C 01	3,900	3,700	4,200	3,800	4,600	3,700	4,200	4,800	5,400	5,300	4,000	3,400
C 02	NS	4,400	3,000	6,200	3,100	3,200	3,600	4,000	3,100	3,300	NS	4,900
C 03	2,300	6,400	3,500	8,300	4,900	2,300	5,400	6,600	5,500	5,500	4,600	4,300
C 04	3,300	1,800	3,800	3,200	5,700	2,900	4,500	4,700	4,200	6,300	5,300	2,400
C 05	1,500	4,800	2,100	2,200	2,500	2,800	4,600	5,400	1,900	5,200	6,600	2,100
C 06	4,900	3,300	2,900	4,900	2,700	1,800	4,900	2,700	3,600	2,600	2,300	3,700
C 08	6,200	6,300	3,300	6,500	5,700	6,000	4,600	6,700	4,900	6,500	6,100	4,700
C 09	5,700	5,200	5,800	7,200	6,500	4,000	6,000	6,100	5,700	6,400	6,200	6,600
C 11	3,700	4,700	4,100	1,100	6,800	5,600	4,600	6,000	4,100	5,200	4,500	4,000
C 12	5,700	6,900	5,800	5,200	4,900	5,900	6,000	5,400	6,700	5,900	6,600	3,800
Zirconium-95:												
C 01	100	300	220	750	940	720	680	840	180	80	190	170
C 02	(a)	240	430	0	560	680	1,200	610	430	320	(a)	200
C 03	140	130	160	300	280	900	150	330	110	70	70	50
C 04	210	310	340	840	520	700	510	750	320	(a)	80	170
C 05	250	240	280	749	580	560	470	480	580	100	170	230
C 06	90	310	340	970	960	960	690	1,200	760	470	320	110
C 08	80	140	200	400	240	310	420	300	300	130	100	(a)
C 09	80	160	230	860	420	810	540	410	250	380	50	(a)
C 11	200	340	280	740	860	610	700	1,500	850	550	450	90
C 12	70	150	200	820	660	360	180	460	380	200	90	80
Ruthenium-106:												
C 01	(a)	410	320	760	610	400	270	410	(a)	(a)	(a)	(a)
C 02	(a)	640	790	(a)	(a)	(a)	360	750	290	370		(a)
C 03	(a)	320	(a)	(a)	(a)	(a)	(a)	200	(a)	(a)	(a)	(a)
C 04	(a)	(a)	400	[c]560	(a)	340	(a)	480	570	(a)	(a)	(a)
C 05	(a)	(a)	(a)	630	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
C 06	(a)	(a)	430	[d]520	(a)	(a)	(a)	660	660	320	[illegible]	(a)
C 08	(a)	(a)	330	320	(a)	(a)	(a)	320	450	360	(a)	(a)
C 09	(a)	(a)	(a)	530	(a)	(a,e)	(a)	400	550	610	(a)	(a)
C 11	200	670	(a)	320	400	(a)	(a)	770	(a)	520	540	(a)
C 12	(a)	140	(a)	[f]650	350	(a)	(a)	(a)	420	(a)	(a)	(a)

---

[a] Less minimum detectable activity.
[b] This value lies outside the range of values expected for this sampling site.
[c] Cerium-144, 760 pCi/kg wet weight.
[d] Cerium-144, 880 pCi/kg wet weight.
[e] Cerium-144, 380 pCi/kg wet weight.
[f] Cerium-144, 640 pCi/kg wet weight.

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C 12 in May and November. No concentrations of gross alpha, gross beta, tritium, or gamma-emitting radionuclides above the minimum detectable activities were found except for a value of 16 pCi/liter gross beta radioactivity in the November sample taken from location C 12.

No radioactivity was detected in the two samples of precipitation collected in November from locations C 07 and C 18.

Seawater was sampled at several locations around the Crystla River site. These samples were analyzed for gross alpha and beta radioactivity, tritium, and gamma-emitting radionuclides. The results of these analyses are presented in table 6.

In early March, a theromluminescent dosimeter network was established at five locations. The results of this network are presented in table 7.

Table 3. Radioactivity in selected types of vegetation Crystal River, 1971

Sampling sites and radionuclide	Palmetto berries (pCi/kg)	Saragassum (pCi/kg)	Saw palmetto (pCi/kg)	Orange (pCi/kg)
C 01:				
Gross beta	8,600			
Cesium-137	180			
Potassium-40	8,700			
C 01:				
Gross beta		5,800		
Gross alpha		3,400		
Potassium-40		6,100		
Zirconium-95		120		
C 02:				
Gross beta			3,400	
Cesium-137			200	
Potassium-40			2,600	
Zirconium-95			250	
C 19:				
February 1971:				
Gross beta				3,160
Gross alpha				533
Potassium-40				3,100
Strontium-90				190
November 1971:				
Gross beta				2,000
Gross alpha				210
Potassium-40				1,800
Strontium-90				85

Table 4. Radioactivity in marine biota, Crystal River, 1971

Vector and sampling site	Concentration (pCi/kg wet weight)															
	Gross beta				Gross alpha				Potassium-40				Cesium-137			
	Feb	May	Aug	Nov	Feb	May	Aug	Nov	Feb	May	Aug	Nov	Feb	May	Aug	Nov
Oysters:																
C 09	1,080				190				640							
C 12	500			900	60				ND			600				
C 14	1,710			1,900	ND				680			1,400				
C 20	1,180	1,490		930	108	109			920	1,100		750				
Blue crab:																
C 01	3,230				1,192				1,200							
C 08	2,550				981				1,200							
C 09		4,180				ND				2,200						
C 12	4,400	3,560	3,340		2,460	1,160	1,380		1,200	1,200	1,600				50	
C 21		2,800	3,203	2,300		1,137	978	1,600		1,700	1,700	1,300			ND	
Pin fish:																
C 21	1,420				ND				ND				890			
Mullet:																
C 08		3,070				800				2,000						
Hard tailjack:																
C 18		4,500				445				2,500						
Fish:																
C 01[a]				3,600				450				2,600				
C 08				4,000				1,100				2,500				
C 11				4,600				1,200				2,700				
C 18[b]				3,700				1,300				2,200				

[a] Strontium-90 concentrations for November 13 pCi/kg for Site C-01; 7 pCi/kg for C-08; 5 pCi/kg for C-11, and 9 pCi/kg for C-18.
[b] Site C-18 showed 21 pCi/kg of strontium-89.
ND, nondetectable.

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Table 5. Radioactivity concentrations in soil and silt samples, Crystal River, 1971

Sampling site	Soil (pCi/kg)									
	Gross beta		Gross alpha		Cesium-137		Potassium-40	Cerium-144	Zirconium-95	Ruthenium-106
	Feb	Aug	Feb	Aug	Feb	Aug	Aug	Aug	Aug	Aug
C 01	([a])	([a])	6,580	([a])	([a])	50	([a])	830	160	190
C 02	([a])	([a])	([a])	([a])	([a])	180	([a])	710	180	230
C 03	([a])	([a])	([a])	([a])	60	1,200	410	900	180	290
C 04	([a])	([a])	([a])	([a])	530	1,300	([a])	580	100	([a])
C 05	([a])	10,700	([a])	9,180	530	1,100	([a])	1,400	310	520
C 06	([a])		([a])		220					
C 07	([a])	([a])		([a])		1,300	([a])	780	130	240
C 08	12,500	7,990	7,250	5,350	2,400	640	([a])	1,100	370	570
C 09	([a])	3,170	([a])	([a])	([a])	([a])	([a])	520	150	240
C 11	([a])	2,830	([a])	([a])	80	320	([a])	920	310	400
C 12	([a])	4,730	([a])	([a])	450	240	460	950	200	400

Sampling site	Silt[b] (pCi/kg)									
	Gross beta				Potassium-40[c]	Cerium-144				Zirconium-95[d]
	Feb	May	Aug	Nov	Aug	Feb	May	Aug	Nov	May
C 01	([a])	([a])	([a])	([a])	([a])	([a])	400	640	570	([a])
C 09	([a])	([a])	([a])	8,200	390	([a])	690	580	670	([a])
C 13	([a])	([a])	([a])	([a])	([a])	([a])	340	([a])	390	([a])
C 14	([a])	7,580	([a])	5,400	490	([a])	290	370	1,100	160

[a] Less minimum detectable activity.
[b] Gross beta radioactivity was less than the minimum detectable activity at all stations for all months.
[c] Potassium-40 was not detectable in samples taken during February, May or November.
[d] Zirconium-95 was not detected in samples taken during February, August or November.

Table 6. Radioactivity in seawater,[a] Crystal River, 1971

Location	Gross [illegible] (pCi/lit[illegible])				Gross alpha (pCi/liter)	Potassium-40 (pCi/liter)			
	Feb	May	Aug	Nov	Feb	Feb	May	Aug	Nov
C 01	NS	NS	54	NS	NS	NS	NS	([b])	NS
C 08	88	51	20	74	4	([b])	([b])	([b])	([b])
C 09	36	108	146	130	7	([b])	([b])	([b])	([b])
C 11	175	287	90	200	16	([b])	([b])	([b])	([b])
C 12	14	NS	21	NS	3	([b])	([b])	([b])	([b])
C 13	244	329	390	340	([b])	280	220	260	280
C 14	377	284	314	330	([b])	210	220	([b])	200

[a] All concentrations of gross alpha radioactivity and gamma-emitting radionuclides were below minimum detectable activities except for those samples listed in the table.
[b] Less than the minimum detectable activity.
NS, no sample.

Table 7. Gross gamma radiation as measured by thermoluminescent dosimeters[a] Crystal River, 1971

Sampling location	Radiation dose rate (μrem/h) Date of removal (1971)								
	4/19	5/12	6/10	7/14	9/9	10/6	11/5	12/15	1/7/72
C 04	22	27	22	20	19	20	19	22	22
C 07	25	20	25	20	18	24	19	25	21
C 08	27	20	31	20	18	25	19	29	21
C 18	21	24	19	23	23	20	23	20	26
C 26	25	36	25	35	34	24	35	31	40
Mean	24	25	24	24	22	23	23	22	26

[a] The TLD's are of the CaF: Mn type. Since the data are being collected to determine any trends in the background rather than absolute measurements, the inherent background radiation of the TLD (due mostly to potassium-40 in the glass envelope was not subtracted from the readings in this table. The average inherent background radiation of these TLD's is 8 μrem/h.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for the Brookhaven National Laboratory.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Brookhaven National Laboratory[2]
January–June 1970

Associated Universities, Inc.
Upton, N.Y.

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by radioactivity in the cooling air from the research reactors (2) by radiation from an ecology forest gamma-ray source, and (3) by low-level radioactive liquid wastes released to a stream that forms one of the headwaters of the Peconic River (figure 1). The radiation levels resulting from reactor air effluent and the ecology forest source are monitored continuously by four stations located at the site boundary. The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the site.

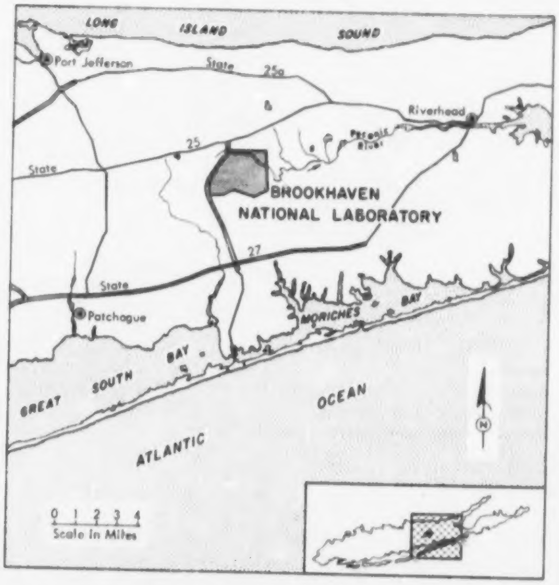

Figure 1. Brookhaven National Laboratory and surrounding area

Table 1. External gamma radioactivity at BNL site perimeter due to laboratory operations, January–June 1970

Date (1970)	Average exposure rates (mR/week)			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast[a] perimeter
January	0.00	0.00	0.00	0.23
February	.00	.00	.00	.25
March	.00	.00	.00	.25
April	.00	.00	.00	.31
May	.00	.00	.00	.33
June	.00	.00	.00	.36
Highest weekly reading (January–June)	0.00	0.00	0.00	0.38
Average undisturbed background (January–June)	1.54	1.77	1.63	1.77

[a] Levels measured continuously at station on former perimeter, 2,630 feet north of source have been adjusted on the basis of periodic measurements at the present perimeter, 3,405 feet north.

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[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the First Half of 1970," Associated Universities Inc., Upton, N.Y. 11973.

Area monitoring

The average weekly radiation levels at the Brookhaven National Laboratory site perimeter (figure 2), due to laboratory operations, are given in table 1. Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to a cesium-137 source located in the nearby forest. The radiation levels at this location were only 2 percent of the established Atomic Energy Commission (AEC) radiation protection standard of 500 mrem/a for individuals in the general population. Values of radiation background levels undisturbed by laboratory operations also have been included in table 1 for purposes of comparison.

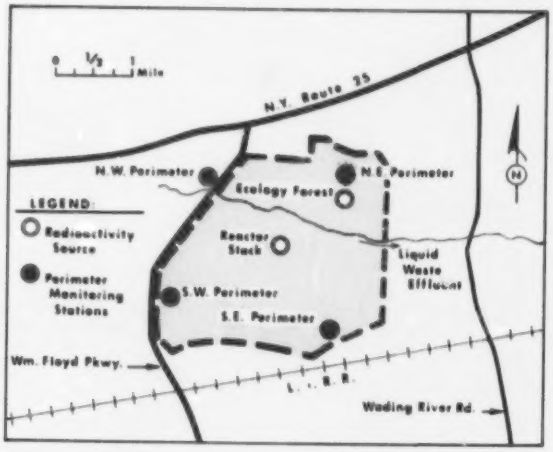

Figure 2. Brookhaven National Laboratory monitoring station locations

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the BNL site. The average concentration and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for January–June 1970.

Analysis of composite samples of the effluent has shown that, on the average, less than 20 percent of the radioactivity consists of strontium-90. No appreciable amounts of radioactive iodine or bone-seeking radonuclides (such as radium) other than strontium, were present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 1 nCi/liter. The observed concentration in effluent was 1.5 percent of the standard.

Most gross beta measurement instruments are not sensitive to low energy beta emitters, such as tritium, for which special analytical methods must be employed. The concentration and amounts of tritium found during this reporting period in the laboratory's liquid waste effluent are also shown in table 2. The applicable AEC standard is 3 μCi/liter, averaged over a period of 1 year. The observed concentration of tritium at BNL was 0.8 percent of this standard.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1969	September 1972

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary January–June 1970

1970 (Date)	Volume of flow (gallons/day)	Average beta radioactivity concentration (pCi/liter)	Total beta radioactivity concentration discharged (mCi)	Tritium concentration (nCi/liter)	Tritium radioactivity (Ci)
January	978,000	12	1.2	3	0.3
February	857,000	11	1.0	12	1.1
March	660,000	15	1.3	75	6.4
April	1,460,000	13	1.9	10	1.6
May	1,180,000	16	2.5	22	3.5
June	1,157,000	25	3.1	30	3.7
Summary January–June	1,130,000	15	11.0	23	16.6

Nuclear Power Reactors in the United States
September 30, 1972

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports*.

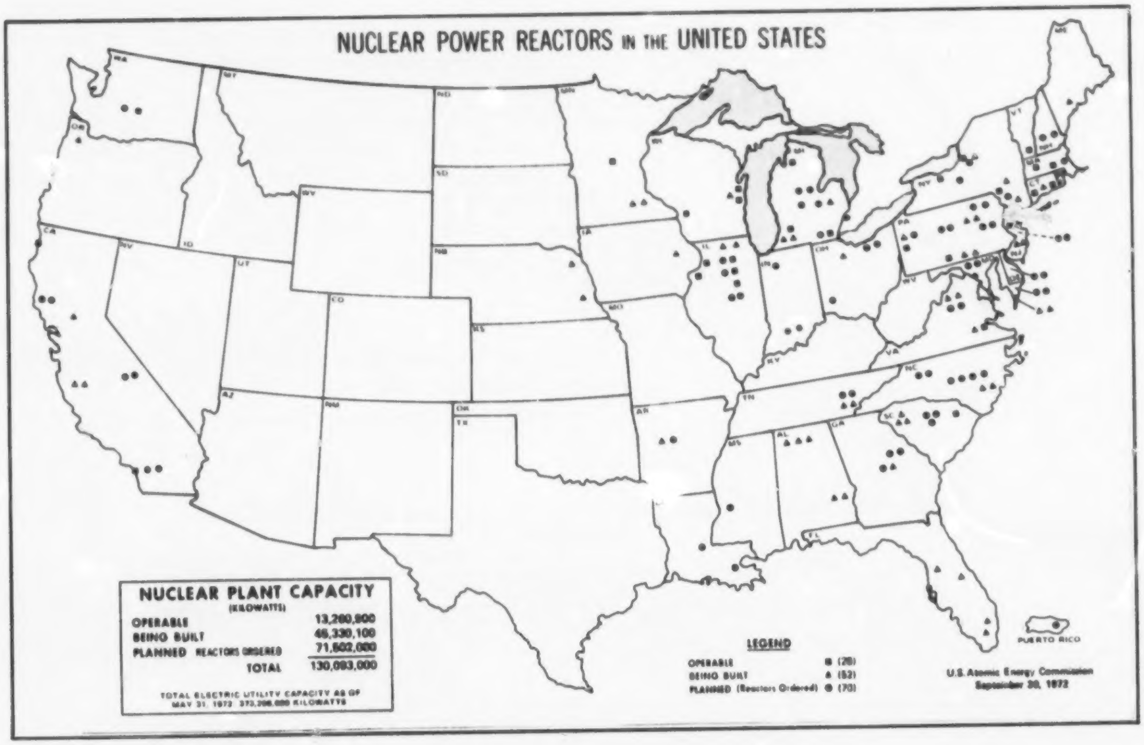
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 13,280,800
BEING BUILT 45,330,100
PLANNED REACTORS ORDERED 71,602,000
TOTAL 130,093,000
TOTAL ELECTRIC UTILITY CAPACITY AS OF MAY 31, 1972 373,298,000 KILOWATTS
LEGEND
OPERABLE ■ (29)
BEING BUILT ▲ (52)
PLANNED (Reactors Ordered) ● (70)
PUERTO RICO
U.S. Atomic Energy Commission
September 30, 1972

Figure 1. Nuclear power plants in the United States

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SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1974
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	920,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	–
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	–
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1973
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1979
•	–	770,000	Southern California Edison Co.	1981
•	–	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1973
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
DELAWARE				
•	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1978
•	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Turkey Point	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	Hutchinson Island: Unit 1	800,000	Florida Power and Light Co.	1975
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,105,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,105,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	800,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	800,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1977
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
•	Comed West: Unit 1	1,100,000	Comm. Edison Co.	1978
•	Comed West: Unit 2	1,100,000	Comm. Edison Co.	1979
•	Comed West: Unit 3	1,100,000		1980
•	Comed West: Unit 4	1,100,000		1981
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1977
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station	1,165,000	Louisiana Power & Light Co.	1976
St. Francisville	River Bend Station	940,000	Gulf States Utilities Co.	1979
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972

Figure 1. Nuclear power plants in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
Perryman	Perryman Nuclear Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1979
Perryman	Perryman Nuclear Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1980
Douglas Point	Douglas Point Project: Unit 1	1,100,000	Potomac Electric Power Co.	1980
Douglas Point	Douglas Point Project: Unit 2	1,100,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	655,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1978
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,124,000	Detroit Edison Co.	1980
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1977
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1978
St. Clair County	Greenwood: Unit 2	1,240,000	Detroit Edison Co.	1979
St. Clair County	Greenwood: Unit 3	1,240,000	Detroit Edison Co.	1981
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station	1,275,000	Mississippi Power & Light Co.	1978
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973
NEW HAMPSHIRE				
Seabrook	–	1,100,000	Public Service of N.H.	1979
Seabrook	–	1,100,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1974
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1978
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1979
Offshore	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Offshore	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1972
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Con. Ed. Nuclear #4	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980

Figure 1. Nuclear power plants in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
OHIO				
Oak Harbor	Davis Besse Nuclear Power Station	872,000	Toledo Edison Cleveland Electric Illuminating Co.	1974
Painesville	Perry Nuclear Power Plant: Unit 1	1,100,000	Cleveland Electric Illuminating Co.	1979
Painesville	Perry Nuclear Power Plant: Unit 2	1,100,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1976
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1976
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	856,000	Duquesne Light Co. Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	856,000	Duquesne Light Co. Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1973
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
*	Philadelphia Electric Co.: HTGR No. 1	1,140,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co.: HTGR No. 2	1,140,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
York County	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
York County	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1975
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1977
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
WASHINGTON				
Richland	N Reactor WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	Hanford No. 2	1,103,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1972
PUERTO RICO				
Puerto De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975

* Site not selected.

*	—	1,175,000	Tennessee Valley Authority	1977
*	—	1,175,000	Tennessee Valley Authority	1978

Figure 1. Nuclear power plants in the United States—continued

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Reported Nuclear Detonations, November 1972

(Includes seismic signals presumably from foreign nuclear detonations)

No nuclear detonations by the United States were reported by the U.S. Atomic Energy Commission for December 1972.

The U.S. Atomic Energy Commission announced that the United States had recorded seismic signals, presumably from a Soviet underground nuclear explosion on November 1, 1972. The signals originated from the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 200 kilotons to 1 megaton.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on November 24, 1972. The signals originated at approximately 5:00 a.m. (EST) November 24, 1972, in the southeastern Ural area of the USSR, and were equivalent to those of an underground nuclear explosion in the yield range of 20-200 kilotons.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

USE OF A FALLOUT CESIUM-137 AS A TRACER TO DEFINE THE RECENT DELTAIC FACIES OF A RIVER. *P. Plato and G. C. Goldman. Radiation Data and Reports, Vol. 13, December 1972, pp. 653-657.*

Using fallout cesium-137 as a tracer, the size and location of the deltaic facies in Lake Michigan of the St. Joseph River are described. Approximately 185 sediment samples were collected and analyzed for cesium-137 aboard ship during five working days. Contour lines are shown that reprsent the measured concentrations of cesium-137 in the deltaic facies produced by the St. Joseph River.

KEYWORDS: Cesium-137, deltaic facies, fallout, Lake Michigan, river-lake interface, sediment, St. Joseph River.